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ABSTRACT

The two student notebooks in this set provide the basic course outline and assignments for the first year of a four year senior high school unified science program. The first volume consists of these three units: The Universe and Man; Man's Attempt to Understand and Relate to the Process of Change; and Man's Ideas About the Structure of Matter. Included in the second volume are these units: The Role of Energy and Time in the Process of Change, Interactions Resulting in Physical Change, and Interactions Resulting in Chemical Change. The materials for each of the sub-units found in the notebook include: a list of required and recommended readings from various other books; questions for consideration in introducing a lesson; a brief background reading; a basic outline of the lectures with space provided within the outline for notes; laboratory activities and investigations; laboratory problem reports and other kinds of assignments (discussion questions, completion questions, problems); and summary statements and review questions. Numerous diagrams and illustrations are included. (PR)

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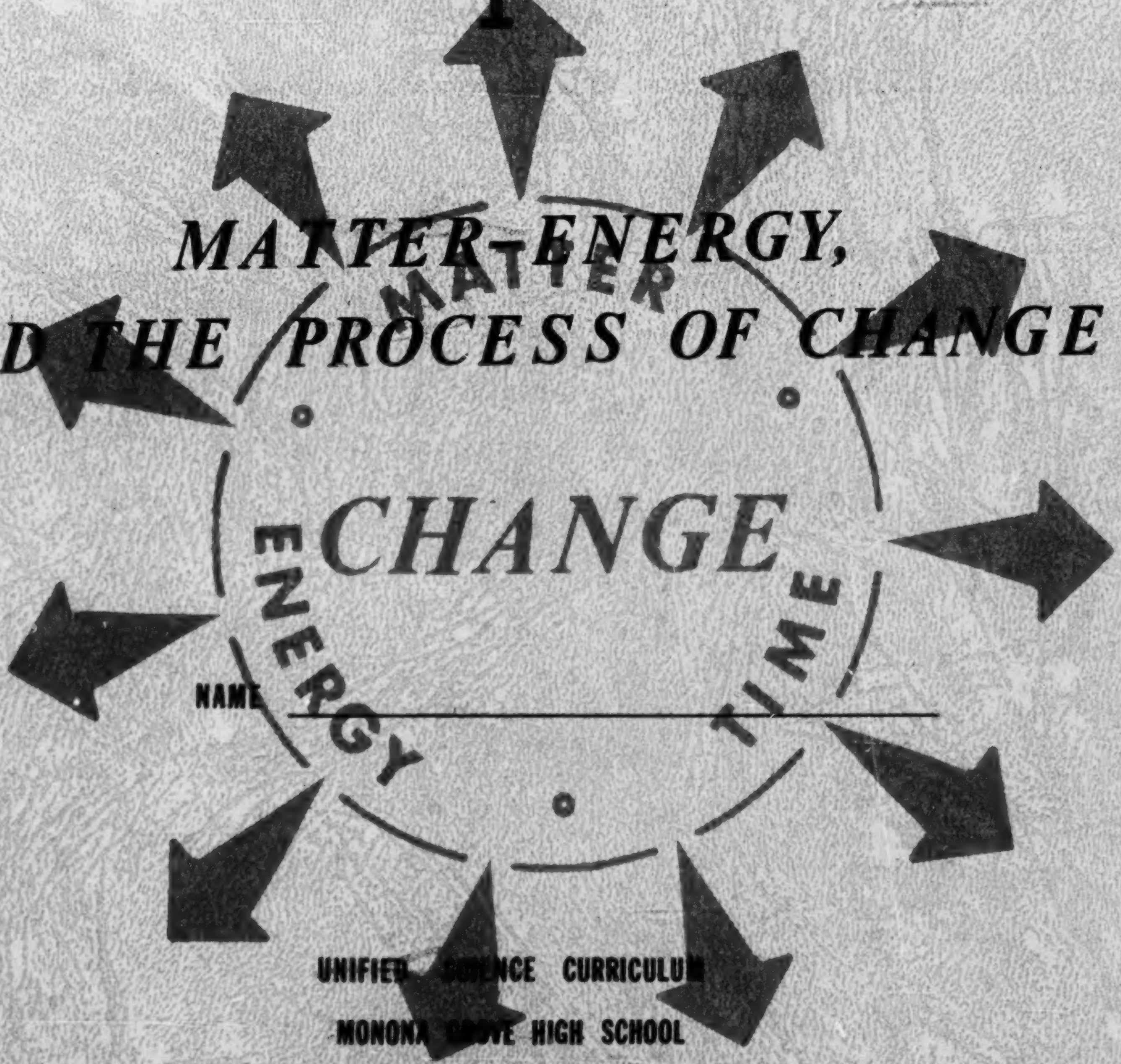
Carl H. Pfeiffer
Wisconsin State Department of Education

SE

SCIENCE
I



MATTER-ENERGY, AND THE PROCESS OF CHANGE

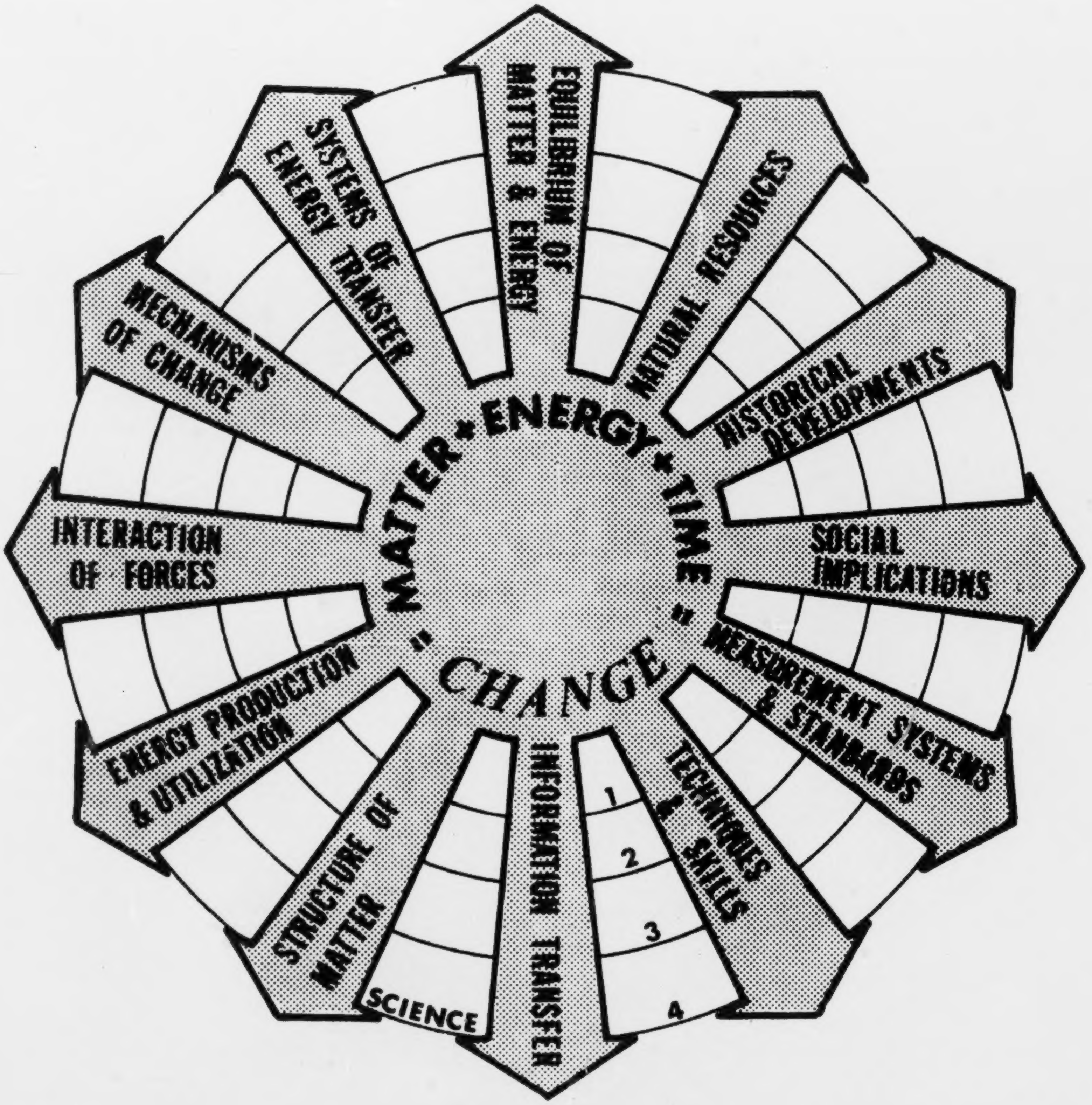
NAME ____

UNIFIED SCIENCE CURRICULUM
MONONA GROVE HIGH SCHOOL
MONONA, WISCONSIN 53716

SE012 308
Part 1

UNIFYING THEMES

MONONA GROVE UNIFIED SCIENCE PROGRAM


EQUILIBRIUM OF MATTER & ENERGY
NATURAL RESOURCES
HISTORICAL DEVELOPMENTS
SOCIAL IMPLICATIONS
MEASUREMENT SYSTEMS & STANDARDS
TECHNIQUES & SKILLS
1
2
3
4
INFORMATION TRANSFER
SCIENCE
STRUCTURE OF MATTER
ENERGY PRODUCTION & UTILIZATION
INTERACTION OF FORCES
MECHANISMS OF CHANGE
SYSTEMS OF ENERGY TRANSFER
MATTER + ENERGY + TIME = CHANGE

INTRODUCTION

I. Class Procedures and Regulations

A. Grouping

1.	Large Groups (50-55 Students)	Rooms -- 67, 61
2.	Laboratory Groups (24 Students)	Rooms -- 61, 73, and 69
3.	Small Groups (15-18 Students)	Rooms -- 61, 73, 69, 67, 65 and other available rooms

When groups move from one room to another during a class session, the movement is expected to be accomplished quickly and quietly.

B. Personal Responsibility in the Classroom

1. When the bell signaling the beginning of a class session sounds, students are expected to come to order without further direction. Students not in their assigned seats at this time are considered to be tardy.
2. Students reporting to class late must present an "admit to class" pass.
3. The class will be dismissed by the teacher, not the bell, at the end of the class session.
4. Students detained by the teacher after the bell should obtain an admit to class pass before leaving the room.
5. Before leaving the classroom!
    a. Check your desk including the shelf and floor area to be sure that they are cleared of debris and in order.
    b. Place your chair under the desk.
6. The science department office located between rooms 61 and 65, is not to be used as a passage way by students.

C. Note Taking

1. The student notebook provides a basic outline of the course content.
2. Regular, careful, note taking in large group sessions is required in order to make the student notebook a useful reference for study.
3. An audio tape on effective note taking is available in the Resource Center.
4. Notebooks will be collected periodically to evaluate the quality of note taking.

D. Assignments

1. Assignment schedules will be given periodically. These schedules should be used to help budget time for homework and study for quiz sessions and hour examinations.

2. Types of homework assignments

   a. Reference reading:

      (1) Reading assignments will be made from selected references located in the Resource Center.

      (2) Generally the required reading assignments will also be available on audio tape.

      (3) "Check tests", one or two questions, will frequently follow a reading assignment.

   b. Problems, exercises and discussion questions:

      Duplicate copies of all problem assignments, exercises and discussion questions appear in the notebook. Carbon copies are handed in for evaluation.

   c. Laboratory reports - to be completed on special laboratory report forms.

3. Regulations pertaining to homework assignments

   a. On days when assignment is due at the beginning of the class session homework will be collected when the bell rings.

      (1) Problems, exercises or discussion questions missing after the collection of homework will be recorded as an F and be reflected in the Individual Performance Grade.

      (2) When excused absence is a factor the F may be converted to full credit provided that the assignment is completed within a specified period.

      (3) Laboratory reports missing at the time of collection will be graded F in Knowledge and Skills and affect the Individual Performance Grade.

      (4) If excused absence is not a factor, late laboratory reports may be submitted for a maximum of ½ credit in Knowledge and Skills.

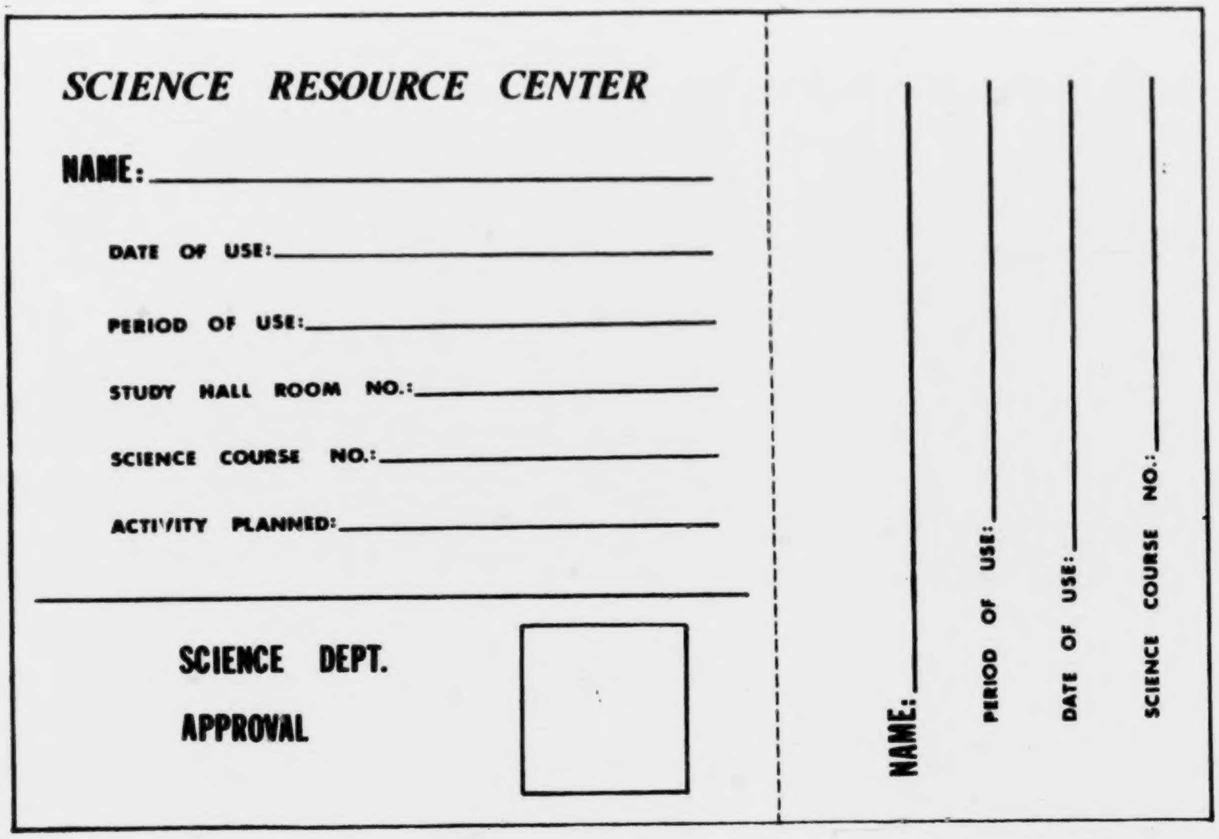
   b. Students absent from class are responsible for arrangements to complete assignments missed.

      (1) Assignments not handed in the day after returning to class will be graded as F, except in cases where requests for an extension of time have been approved.

      (2) Arrangements for making up a scheduled quiz or an hour examination must be completed the day the student returns to class. Any quiz or hour exam not made up will be averaged as F in the Knowledge and Skills Grade.

II. Science Resource Center

A. Use of the Resource Center Facilities



SCIENCE RESOURCE CENTER

NAME: ____________________

DATE OF USE: ____________________

PERIOD OF USE: ____________________

STUDY HALL ROOM NO.: ____________________

SCIENCE COURSE NO.: ____________________

ACTIVITY PLANNED: ____________________

SCIENCE DEPT.
APPROVAL ☐

NAME: ____________________

PERIOD OF USE: ____________________

DATE OF USE: ____________________

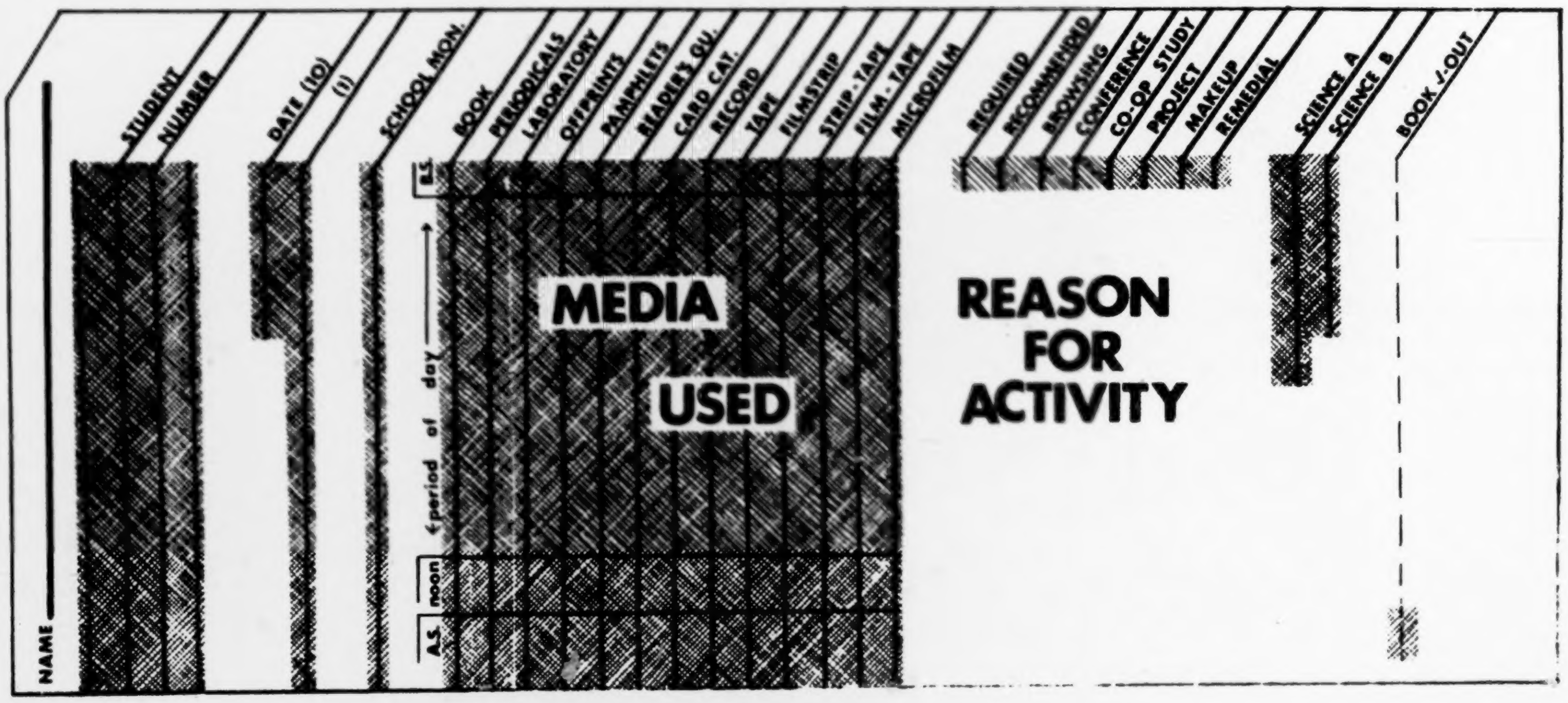
SCIENCE COURSE NO.: ____________________

1. The Resource Center may be used during any regularly scheduled study hall period by the "pass" system.
2. The Resource Center will be open from 12:15 to 12:45 every Tuesday, Wednesday, and Thursday noon.
3. Students wishing to use the Resource Center Facilities before or after school may do so by appointment.
4. Students must demonstrate the degree of self discipline necessary for effective independent or cooperative study in the Resource Center.

B. Circulation of Resource Center Reference Materials

1. No materials will be checked out during the school day.
2. Books, magazines, offprints, and special materials may be checked out on an "overnight" basis only. Check out period is from 3:45 to 4:00 p.m. daily.
3. All materials must be returned by 8:00 a.m. the next day.
4. Failure to comply with any of the above procedures will be reflected in the Citizenship Grade.

C. Use of the Porta-Punch Card


NAME
STUDENT
NUMBER
DATE (10)
(1)
SCHOOL MON.
BOOK
PERIODICALS
LABORATORY
OFFPRINTS
PAMPHLETS
READER'S GU.
CARD CAT.
RECORD
TAPE
FILMSTRIP
STRIP-TAPE
FILM-TAPE
MICROFILM
E.S.
←period of day→
noon
A.S.
MEDIA
USED
REQUIRED
RECOMMENDED
BROWSING
CONFERENCE
CO-OP STUDY
PROJECT
MAKEUP
REMEDIAL
REASON
FOR
ACTIVITY
SCIENCE A
SCIENCE B
BOOK ✓-OUT

1. Print your name on the card.
2. Punch out the correct information on the shaded (red) area.

D. Guide to Student Use of the Science Resource Center

1. The Science Resource Center is designed and equipped to provide an opportunity for students to do independent or cooperative study in the area of science.
2. Students who come to the Resource Center must have a specific purpose which requires the use of the facilities in the Center!
3. Students who use the Resource Center Facilities must record the nature of their activity in the Center by use of the Porta-Punch Card.
4. All cooperative study between two students must be done at the conference tables. Students sitting at the study carrels are expected to work individually without any conversation with other students.
5. All students are encouraged to take advantage of the opportunities that the Resource Center provides for individual help with any problems or difficulties experienced in their science course.
6. The use of the Resource Center Facilities requires self discipline on the part of the student in order to develop effective individual study skills. Students who are unable to exercise the self discipline required to maintain an atmosphere conducive to independent study will not be permitted to use the Resource Center Facilities until such time that they can demonstrate this ability.
7. Maintenance Responsibilities
   a. Turn volume off when headsets are not in use.
   b. Leave all reference books on the carrel shelf in good order. All cataloged books and periodicals are to be returned to the proper space in the drawers or shelves.
   c. Keep desk storage area free of debris and desk surfaces clean.

III. Grades and grading

A. Basis for the evaluation of Individual Performance and School Citizenship:

*See accompanying sheets or student handbook for points considered in grading these categories. Individual Performance and School Citizenship will be evaluated three times each quarter.

B. Basis for the evaluation of student progress in the area of Knowledge and Skills:

1. The grade point system

4.0 3.9 3.8	4.3 A+
3.7 3.6 3.5	4.0 A
3.4 3.3 3.2	3.7 A-
3.1 3.0	3.3 B+
2.9 2.8 2.7	3.0 B
2.6 2.5	2.7 B-
2.4 2.3 2.2	2.3 C+
2.1 2.0 1.9	2.0 C
1.8 1.7 1.6	1.7 C-
1.5 1.4	1.3 D+
1.3 1.2 1.1	1.0 D
1.0 .9	.7 D-
.8 .7 .6 .5	.3 F+
.4 .3 .1 .0	.0 F

2. Determination of grade point

Daily Work - ½ of Knowledge and Skills Grade

Quizzes a. short 5 minute unannounced test covering material presented in large group sessions or homework assignments

b. 15-30 minute announced test

Written laboratory problem and investigation reports

Hour Examinations - ½ of Knowledge and Skills Grade

Daily work and hour examinations not completed will be averaged as zero.

C. Final Total Growth Grade

1. Each of the four, quarterly, total growth grades plus the Final Evaluation are averaged equally to give the final Total Growth Grade in the course.

2. Final Evaluation

a. The final written examination in the course will count as one-half of the Final Evaluation.

b. A final appraisal of Individual Performance and School Citizenship will determine the remaining half of the Final Evaluation Grade.

FACTORS DEFINING INDIVIDUAL PERFORMANCE

Works up to ability

1. Does work which compares favorably with ability as measured by test scores.
2. Does daily work which compares favorably with best work done in a grading period.
3. Tries to make the best use of his particular talents and opportunities.
4. Carefully completes each day's assignment.
5. Reworks and corrects errors in assignments after class checking.
6. Goes beyond regular assignments to learn more about the subject.
7. Spends time reviewing.
8. Shows improvement rather than staying at one point.

Has a positive attitude

1. Has a sincere desire and interest in learning.
2. Is willing to try - is willing to be exposed to new information and ideas.
3. Has respect for the opinions of others.
4. Accepts correction well and constantly tries to improve.
5. Takes pride in his work.
6. Responds as well to group instruction as to individual instruction.
7. Does not argue over trivial points.
8. Does not show negative feelings in class - straightens things out alone with teacher.
9. Is willing to accept special jobs.

Shows self-direction

1. Demonstrates ability to carry on independent or cooperative study using Resource Center materials.
2. Works for understanding rather than a grade.
3. Is self-starting and self-sustaining.
4. Does his own work - has confidence in it.
5. Tries assignments himself before seeking help.
6. Knows when and how to seek help.
7. Initiates makeup assignments and does them promptly.
8. Is resourceful- uses imagination.
9. Settles down to work immediately.
10. Shows initiative.

Plans work wisely

1. Completes assignments and turns them in on time.
2. Is prepared for class - brings all necessary materials.
3. Makes good use of study time.
4. Follows directions.
5. Anticipates needs in work projects.
6. Organizes time so there is no last minute rush job.
7. Moves quickly and quietly when given an assignment.

FACTORS DEFINING SCHOOL CITIZENSHIP

Is courteous and considerate of others

1. Is courteous to other students, to teachers or any person with whom he comes in contact, for example the custodial staff.
2. Is quiet and attentive in class discussion.
3. Listens carefully to student questions, answers and comments as well as to those of the teacher.
4. Uses only constructive criticism - avoids ridicule.
5. Is tolerant of errors made by others.
6. Receives recognition before speaking.
7. Is ready to begin work when the bell rings.
8. Accepts the "spirit" as well as the letter of school regulations.
9. Shows halllway conduct which is orderly and in good taste.
10. Shows good assembly conduct.
11. *Is quiet and* attentive during P.A. announcements.
12. Is quiet in hallways when school is in session.
13. Carries out classroom activity in a quiet and businesslike manner.

Is responsible

1. Demonstrates self discipline necessary for effective use of Resource Center Facilities.
2. Keeps appointments.
3. Carries out assigned tasks.
4. Can be left unsupervised for a period of time.
5. Gets to class on time.
6. Meets obligations, fees, etc.
7. Returns borrowed items.
8. Has a good attendance record.
9. Keeps name off library list.
10. Presents excuse for absence.
11. Returns report card on time.

Contributes his share

1. Works to develop and uphold the good reputation of the school.
2. Participates in class discussion in a constructive manner - asks questions as well as volunteering information - shares ideas.
3. Participates in at least one school activity as a cooperative, contributing member.
4. Accepts jobs such as taking part in panels, putting up bulletin boards, helping direct class activities, getting information.
5. Brings examples, clippings, supplementary materials to class.
6. Contributes to success of class in a physical way - straightens chairs, pulls blinds, etc.

Is a good leader or follower

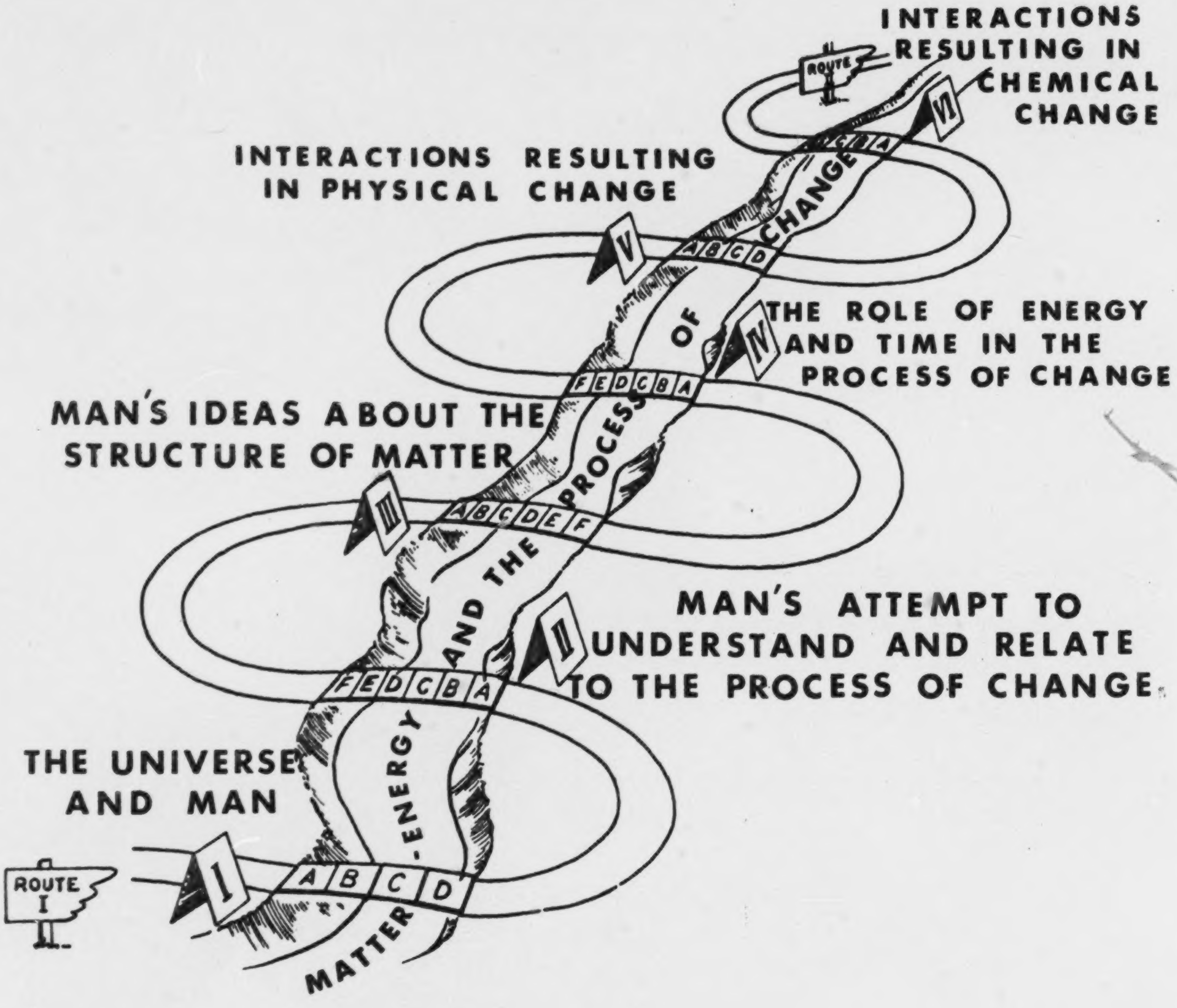
1. Cooperates willingly with the majority even though his point of view is with the minority.
2. Works constructively to change practices he is not in agreement with.
3. Works willingly with any group, not just his particular friends.
4. Helps class move along positively.
5. Leads in class discussion.
6. Responds to suggestions.

7. Gets others to participate.
8. Helps other students learn without simply giving them answers.
9. Is compatible with the group or class.
10. Avoids trying to be the center of attention.

Takes care of school and personal property

1. Handles and uses school equipment and materials with care.
2. Cooperates in keeping school building and grounds clean, free from litter and in excellent condition.
3. Is concerned about clean-up at the end of a class period.
4. Erases pencil marks and picks up paper when others have been careless.
5. Respects property of others.
6. Returns materials to correct places.
7. Avoids marking desks, books, etc.
8. Covers text books.
9. Disposes of gum, paper, etc., properly.
10. Keeps locker clean.

SCIENCE IA


ROUTE I
I
A B C D
THE UNIVERSE AND MAN
II
F E D C B A
MAN'S ATTEMPT TO UNDERSTAND AND RELATE TO THE PROCESS OF CHANGE
III
A B C D E F
MAN'S IDEAS ABOUT THE STRUCTURE OF MATTER
IV
F E D C B A
THE ROLE OF ENERGY AND TIME IN THE PROCESS OF CHANGE
V
A B C D
INTERACTIONS RESULTING IN PHYSICAL CHANGE
VI
C B A
INTERACTIONS RESULTING IN CHEMICAL CHANGE
ROUTE
MATTER-ENERGY AND THE PROCESS OF CHANGE

> "To everything there isa season, and a time to every purpose under the heaven."
>
> Ecclesiastics

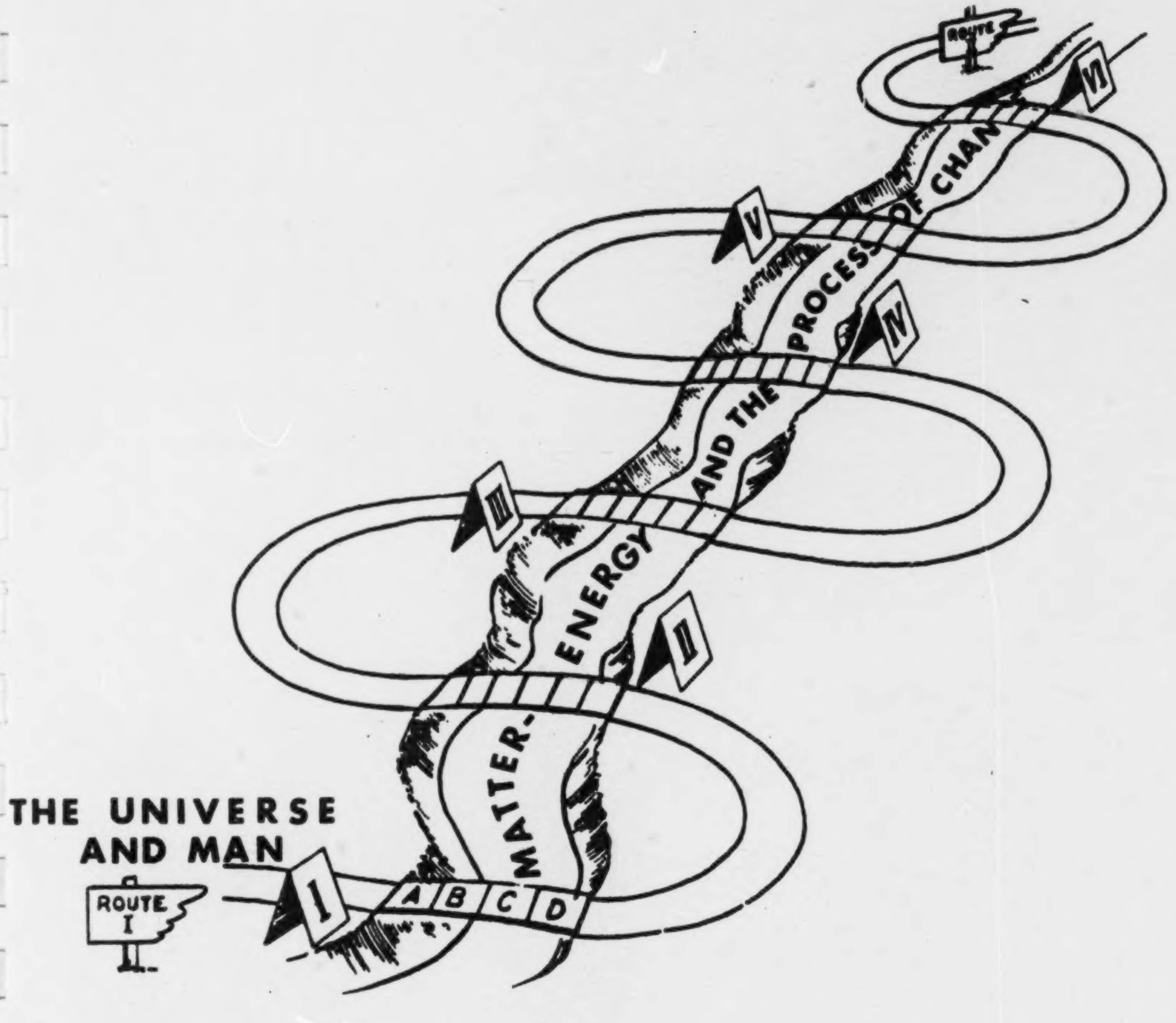
Matter and Energy comprise the world in which we live. They constantly interact and the product of the interaction, with time, is change.

In the process of science, we seek to gain a clearer understanding about the events that lead to change. We are primarily interested in the end product of a chain of events because it is the changes that occur that affect us directly. It is important to realize that we live in a changing world. In order to survive, we must change. Every life process, for example, is a continuous succession of change. From the standpoint of man and his particular relationship to the world it is essential to note that man is able to exercise some control over the processes that produce change. It is because of this fact that man has been able, not only to survive, but to adjust his environment in such a way as to provide for his wants as well as his needs. By exercising control over certain aspects of his changing environment, man has been able to make his existence more comfortable, more convenient, and more meaningful.

It is because man has this ability that the whole process of living becomes an enjoyable and thrilling experience. Imagine, if you can, what it would be like to live in a world in which you could not control one single process of change, a world in which you were completely dependent upon the chance occurrence of changes suited to your continued survival. This is somewhat like the relationship that an infant, at birth, has with his environment. It is only as the infant grows and learns that he is able to exercise some control over that which happens to him.

All of us, as we continue to live, seek to control the things that happen to us in such a way as to make our life pleasant and meaningful. The process of science is one of the ways by which this may be accomplished. The purpose of science is to help the individual to understand himself and the world in which he lives, to understand the relationships between the changes which he experiences personally and those which go on outside of himself. This kind of understanding leads to an awareness of purpose and opportunity. It is the difference between simply existing in the world and becoming an important and useful part of it.

> "to everything there is a season, and a time to every purpose under the heaven: a time to be born, and a time to die; a time to plant, and a time to pluck up that which is planted; a time to kill, and a time to heal; a time to break down, and a time to build up; a time to weep, and a time to laugh; a time to mourn, and a time to dance; a time to cast away stones, and a time to gather stones together; a time to embrace, and a time to refrain from embracing; a time to get, and a time to lose; a time to keep, and a time to cast away; a time to rend, and a time to sow; a time to keep silence, and a time to speak; a time to love, and a time to hate; a time of war, and a time of peace."


THE UNIVERSE
AND MAN
ROUTE
I
I
A
B
C
D
MATTER-
ENERGY
AND THE
PROCESS
OF CHAN
II
III
IV
V
VI
ROUTE

THE UNIVERSE AND MAN.

A. Basic Questions About the Universe.

B. The Earth, It's Position in the Universe.

C. Man's Early Concepts of the Earth and the Universe.

D. Man and Science in the Changing Universe.

REFERENCE MATERIAL AVAILABLE FOR UNIT ONE

The Mystery of the Expanding Universe	523.1
Atoms and the Universe	539.1
Matter, Earth and Sky	500
The Nature of the Universe	523
The Universe	523.1
The Universe at Large	523.1
Astronomy of the 20th Century	520
The Earth We Live In	551
The Birth and Death of the Sun	523.7
The Universe (Life Science Library Series)	
The Planet Earth	525
A Planet Called Earth	551
The Ambidextrous Universe	523
How Old is the Earth?	550.1
The Changing Universe	523
The Restless Universe	530.1
The Universe and Dr. Einstein	530.1
One, Two, Three, Infinity	500
Only a Trillion	504
This is Outer Space	523
The Steady State Universe (Sc. Am. Repr. #218)	
The Evolutionary Universe (Sc. Am. Repr. #211)	
The Red-Shift (Sc. Am. Repr. #240)	
The Cosmic View	500
The World We Live In (Life Family Series)	574
The Earth (Life Nature Series)	550
Fact and Fancy	290
Ours Is The Earth	551.1

Science IA
Resource Material

BASIC QUESTIONS ABOUT THE UNIVERSE

Required Reading: The Mystery of the Expanding Universe, Bonner (523.1 Bo), pages 7-11, 15-19, 23-37

Recommended Reading: A Short History of the Universe, Gregor (523.1 $G81_5$)(L), pages 3-14, 27-45

Audio Tape: Same Titles
Audio Visual Program: "World Famous Observatorics"

QUESTIONS FOR DISCUSSION

1. What is the universe?

2. How big is the universe? Is the universe finite or infinite?

3. How are interstellar distances measured? What are the limitations of these techniques?

4. What is the relative position of our planet earth in the universe?

5. Is the universe changing? How do we know?

6. How old is the universe? What techniques are used to establish the age of the universe?

7. What is the essence of two current theories which attempt to account for the origin of the universe?

BASIC QUESTIONS ABOUT THE UNIVERSE

Introduction

Boundaries to the realm of science may exist only in the minds of men. Certainly, from the time of ancient man's first inquisitive investigations of the world about him, the boundaries of man's understanding of the realm of science have been extended. Today they range in scope from the ultramicroscopic dimensions of sub-atomic particles to the astronomical distances between galaxies in space and beyond. Someplace between these dimensions in space, between that which is too large and that which is too small for the mind of man to comprehend, stands man.

Man, by nature, tends to be self-centered, and as a result, is prone to think of himself as the center of all things.

Typical of this attitude was man's early concept about the universe. He considered the earth, as the abode of man, to be the center of the universe and that all other bodies in the universe rotated about the earth. Through the centuries we have come to understand that this is not the case.

The earth is, in fact, a relatively small planet, belonging to a medium size star, which is but one of billions of stars located on the fringe of a particular galaxy or "cluster of stars" which we call the Milky Way. Even this does not represent the boundary of our universe for there is physical evidence that our own galaxy of stars is but one among uncounted billions of similar galaxies moving about in space.

But, what is space? How big is this universe? Is it flat or curved? When did it begin? Is it changing?

When one asks questions such as these, and even more important tries to find answers for them, the idea of man and earth as the hub about which the rest of the universe revolves, quickly breaks down.

As yet, not one shred of knowledge about the nearby moon, has been obtained by first hand experience, and yet a great deal has been learned about the moon and the universe beyond. Man has learned how to build and use devices which enable him to make accurate observations and measurements far into the regions of space. He has found that the material substance composing the galactic bodies in space is the same as the substance which composes the earth and all things within, on, and above the surface of the earth. The forces that act upon and within the material which composes the stars in space beyond our earth are exactly the same as the forces that act upon the smallest structure we can identify on earth. The types of changes caused by the action of these forces in space are the same as the changes that take place in the material composing the smallest structure we know on earth.

This should not be surprising. It is only man's self-centered attitude about his position in the universe which may make it seem so.

As we seek to learn more about the world in which we live and our relationship to it, we must try to keep man and earth in proper perspective with reference to the universe.

Frequently we will find it easier to understand and appreciate the intricacies of a particular process being studied on earth by first observing the same basic process, or a similar process, on a much larger scale in the universe.

Standing back, and taking the "cosmic view" from time to time helps us to get our bearings. Unless we do this we are like the man who never saw the forest because of the closeness of the trees. As we investigate the nature of our environment and our relationship to it, we shall frequently shift our point of view from the macrocosm, the universe itself, to the microcosm, its twin in miniature (the atom), for each has much to teach us.

In order to more fully appreciate man's relative position in the organization of things in the universe, we will begin our study by asking such questions as: How big is the universe? What is its shape? When did it begin? Is it changing? We shall then consider some of the opinions that have been given by persons who have spent years searching for the answers.

BASIC QUESTIONS ABOUT THE UNIVERSE

I. The Solar System

  A. The Planets

    1. What is a planet?

    2. Number and position of planets in the solar system

  B. Motions of the Planets

    1. Rotation about an axis

    2. Orbital motion around the sun

    3. Motion within the galaxy

    4. Rotation of the Galaxy

    5. Movement of the galaxy through space

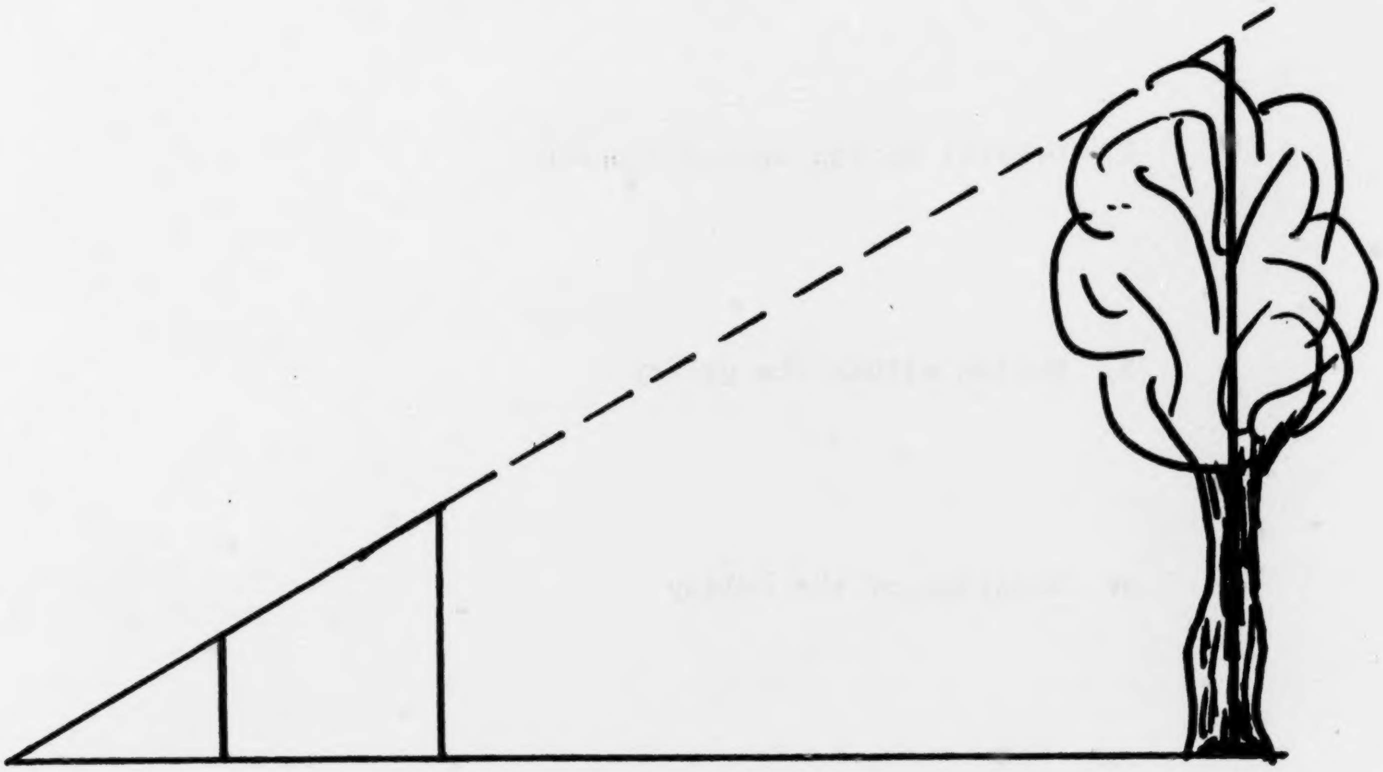
C. Dimensions of the Solar System

D. The Position of the Solar System in the Galaxy

II. Optical Methods of Measuring Distances in Space

A. Triangulation

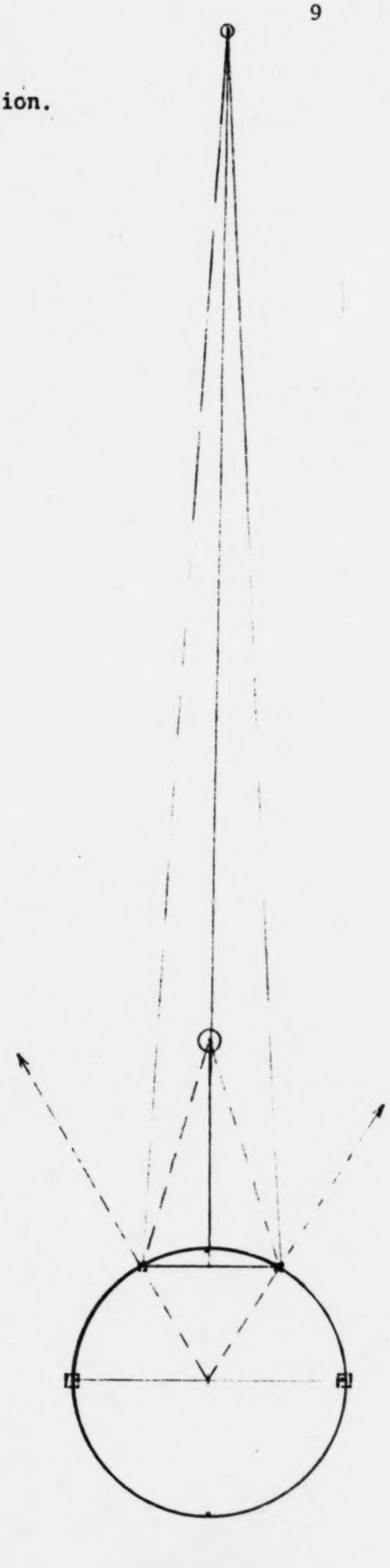
1. Right angle theory.



2. Distance measurements by triangulation.

a. Technique

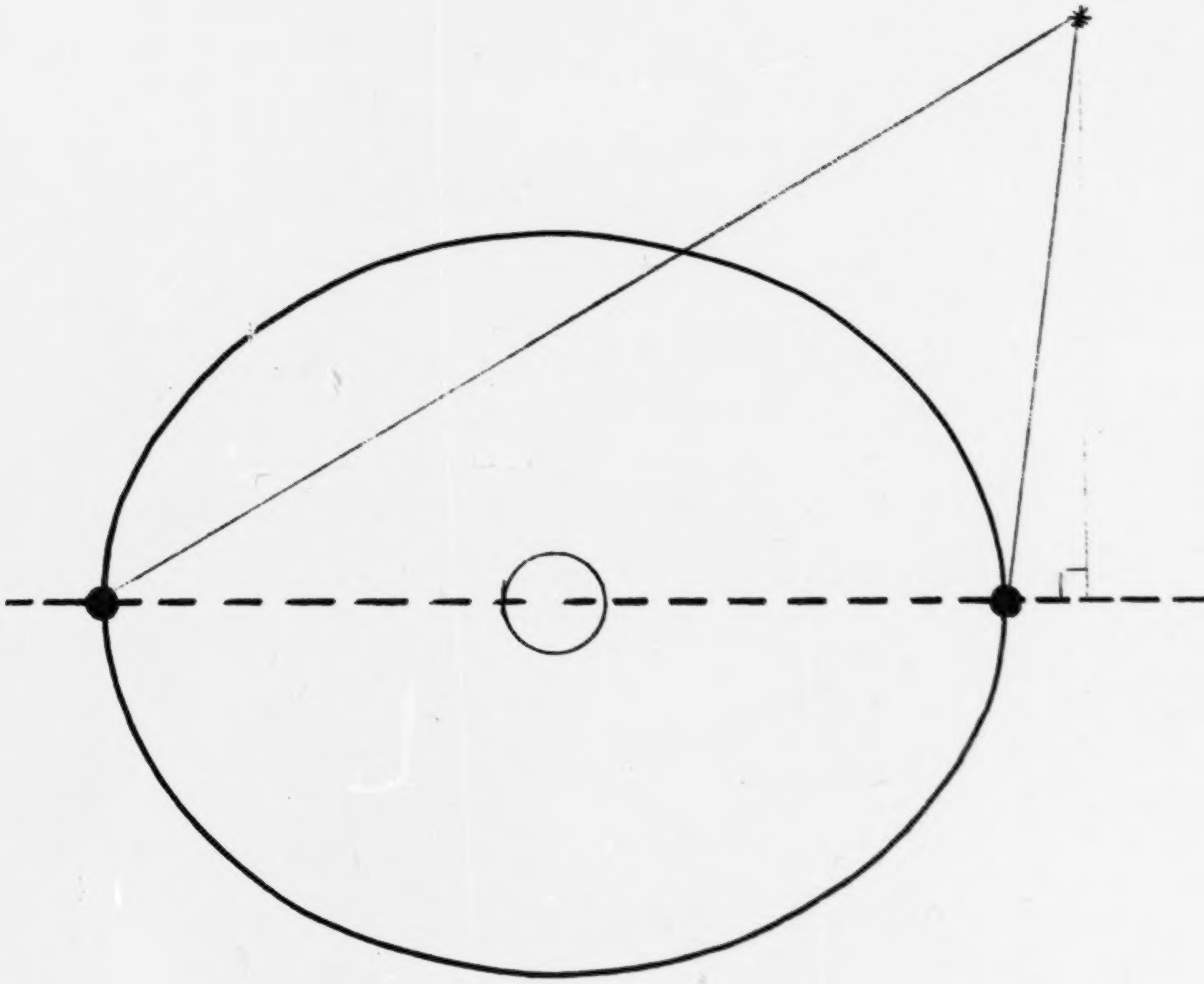
b. Limitations



B. Parallax

1. Technique.

2. Limitations and range.



C. Brightness

1. Apparent brightness.

2. Absolute brightness.

3. Cepheids

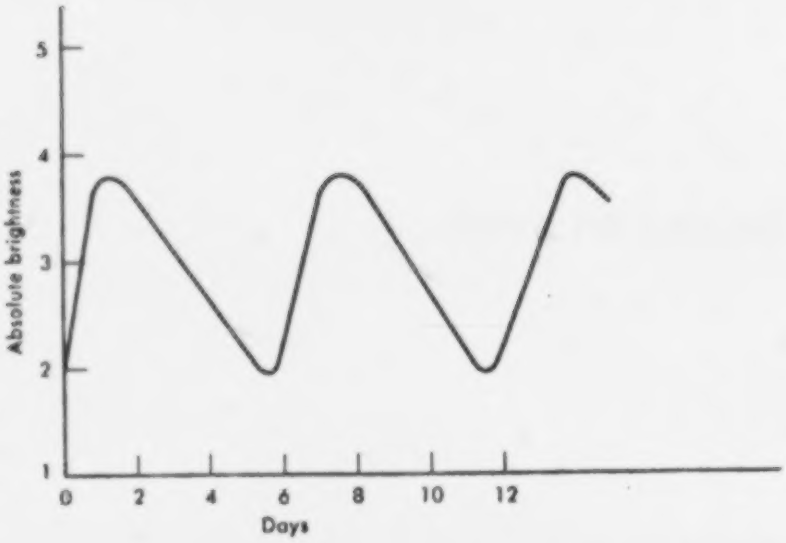
The material on page 11 may be found

TITLE The Universe at Large

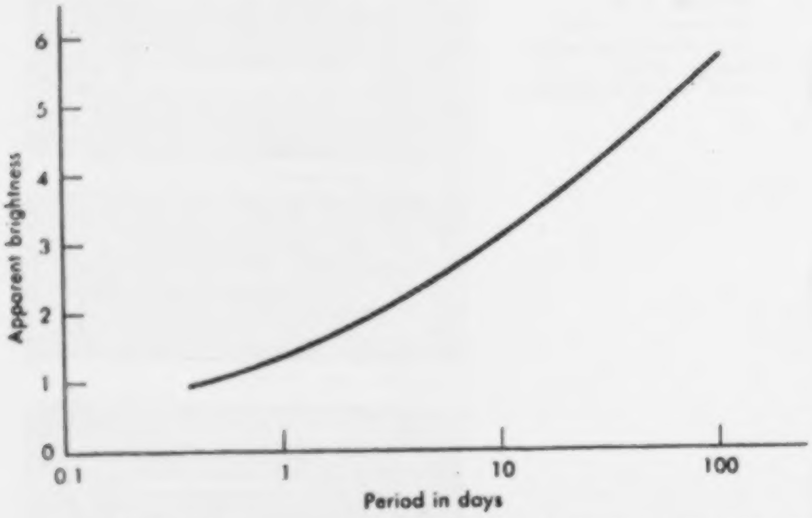
AUTHOR Hermann Bondi

PUBLISHER Doubleday & Company, Inc.

PAGE NO. 40; Plate 1



THE FLUCTUATIONS OF A CEPHEID VARIABLE STAR. The rise to the maximum is much steeper than the subsequent fading. The star is about twice as bright at the maximum as at the minimum.



APPARENT BRIGHTNESS OF CEPHEIDS PLOTTED AGAINST THEIR PERIODS OF OSCILLATION. Miss Leavitt discovered that when the apparent brightnesses of the Cepheids in the Lesser Magellanic Cloud are plotted against their periods, the points lie on a smooth curve like the one shown.

Name ______________________________

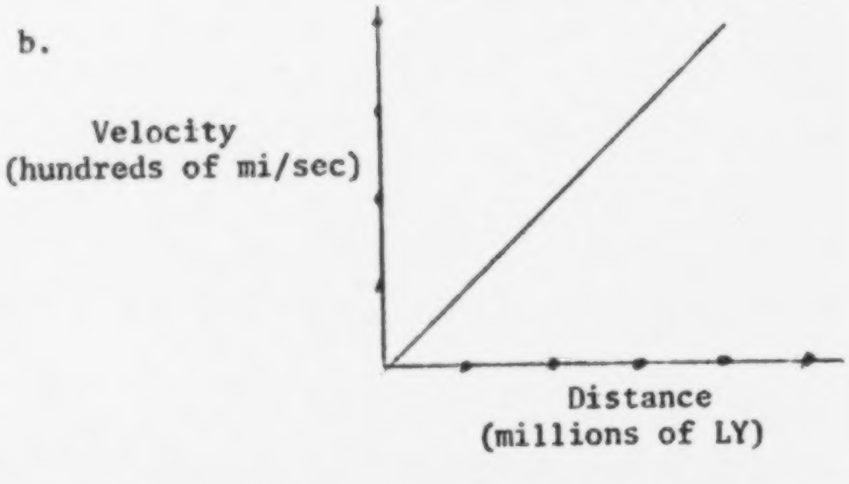
Science I ___ Hour ________

4. Range of brightness method.

D. Red Shift

1. Historical development.
    a. Christian Doppler - 1842
    b. Sir William Huggins - 1868
    c. V.M. Slipher - 1917
    d. Edwin P. Hubble - 1929
2. Hubble's Law.
    a. Visual evidence of spectral shift.

    b.



    c. Calculation of intergalactic distance by measurement of Red Shift.

III. The Galaxies

   A. Milky Way Galaxy

      1. Closest stars.

      2. Distant stars.

   B. Types of Galaxies

      1. Regular.

      2. Irregular.

   C. Distribution of Galaxies in Space

      1. Cluster.

      2. Near cluster "local group".

      3. Other clusters.

IV. Instruments Used to Measure Distance in Space

   A. Light Telescopes

      1. Refracting.

      2. Reflecting.

   B. Radio Telescopes

      1. Australia

      2. Jodrell Bank

V. Ideas Basic to the Building of a Theory About the Universe

A. The Cosmological Principle

B. An Expanding Universe

C. Experimental Evidence in Support of These Ideas

1. Darkness of the night sky.

2. "Red Shift".

3. Uniform distribution of galaxies in space.

VI. Present Theories about the Nature of the Universe

A. Evolutionary Theories

B. Steady State Theories

C. Summation of Current Ideas in Cosmology

VII. Two Fundamental Questions

A. Is the Expansion of the Universe Slowing Down?

B. Is Space Curved or Flat?

Name ______________________________

Science I____ Hour _______

Date ______________________________

BASIC QUESTIONS ABOUT THE UNIVERSE

Read the following paragraph very carefully. Interpret what you read in terms that you believe to be true about the nature of the Universe. Having done this, formulate four questions which you would like to ask relative to what has been said here.

A famous British astronomer who supports the "Steady State Theory" believes that the galaxies we see today, including the Milky Way, are growing old. As they grow old, they travel farther and farther apart. The Universe does not empty out, however, because new galaxies are being formed out of the tremendous quantities of hydrogen that exists in intergalactic space. He goes on to say that the idea of a "Big Bang" is not needed to explain why the universe is getting larger. He points out that the pressure of the hydrogen gas, which is continually being created, forces the universe to expand. Just as a toy balloon expands to make room for your breath, so the universe must expand to make room for newly formed hydrogen. The hydrogen collects in vast galactic clouds. The clouds break up into smaller clouds which then condense into stars.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

Summary of Ideas

1. The universe is expanding. There is some evidence that the rate of expansion might be slowing down.

2. Hubble's Law is (at least roughly) correct:

   $v = Hr$

   vel (red shift) = constant x distance

   Galaxies most distant from us have the greatest velocity of recession.

3. The "expansion" is the most important feature of all cosmological theory.

4. The universe, at any given time, looks the same to galactic observers everywhere. What each observer sees is an average distribution of galaxies showing a red shift.

5. The average density of matter in the universe should, at a given time, be the same everywhere. This cannot be verified because we cannot see all parts of the universe at the same time. We see it now as it was.

6. About 99 percent of the universe is composed of hydrogen. The remaining one percent consists of heavier elements generated in stars.

7. Observations of objects within our Milky Way show the "age of the universe" to be at least 5 billion years. There is no evidence for an upper age limit.

8. At the present time existing physical evidence favors the relativistic theories. No existing theory gives a completely satisfactory explanation of the universe as we know it.

THE STEADY STATE THEORY

1. The universe, as a whole, does not change. It is the same today as it was one billion years ago. "The perfect cosmological principle" - neat and simple.

2. The universe had no beginning and will have no end.

3. The universe does expand but new matter is created at just the right rate to maintain a uniform density (continual creation). Continual creation would require only about one hydrogen atom per liter of space each trillion years.

4. Not all of the galaxies are the same age.

5. The universe is infinite and has no boundaries.

Major Objections:

1. Creation of matter from nothing - violates the Law of the Conservation of Matter and Energy.
2. Present evidence does not indicate the age variations of galaxies that the steady state theory predicts.
3. Evidence of new galaxies? Summer - 1968

EVOLUTION THEORIES

1. The universe as a whole undergoes continuous change in the course of time - it is expanding.

2. The same amount of matter which now fills the universe was once compacted into a single mass under tremendous heat and pressure (100 million tons/inch - 10 billion degrees C°), (1 x 10^{14} g/cm^3).

3. Some sort of nuclear explosion occured causing the matter to expand rapidly. (The universe "began" with an explosion).

   Three phases to the expansion:

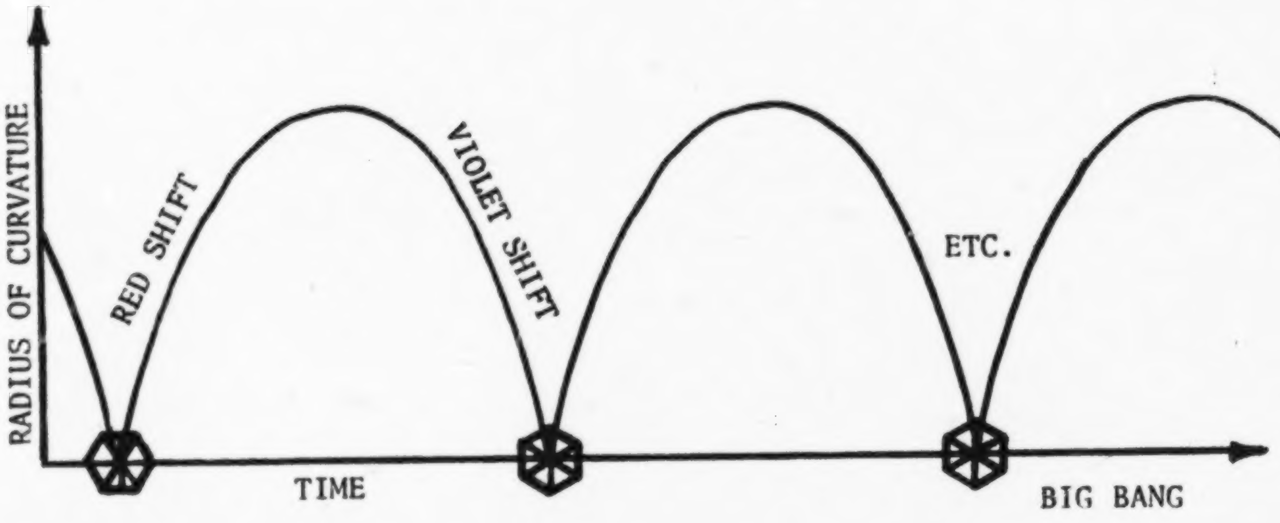
   a. Initial Explosion: rapid expansion (30 min.), intense temperature of 10 billion degrees.

   b. Middle Period: rate of expansion slowed down by forces of gravity, temperature cools, matter condenses to form galaxies of stars, galaxies all most at rest.

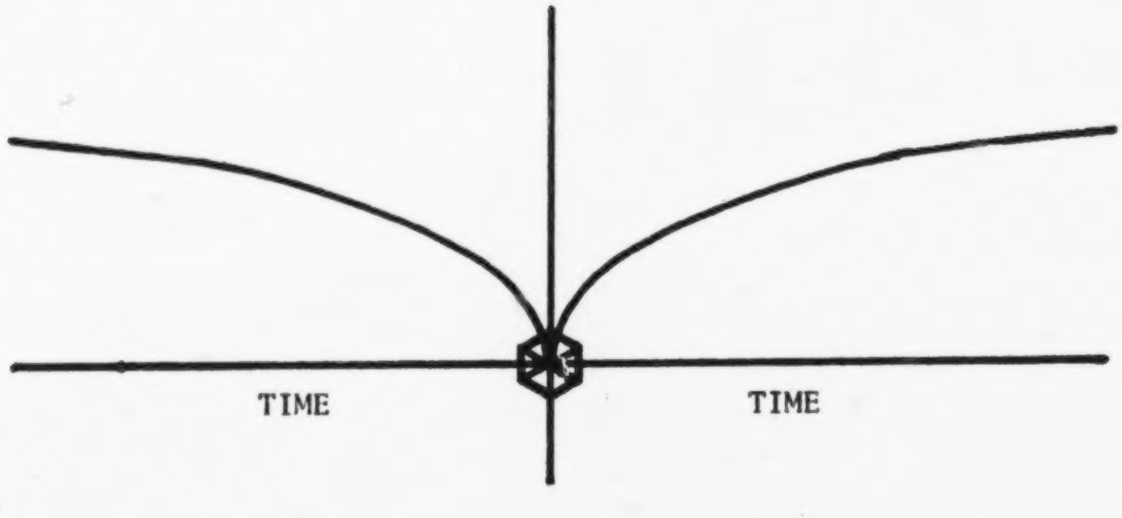
   c. Old Age: acceleration continues and galaxies rush away from each other.

4. All galaxies were formed at the same time, all are approximately the same age - any evidence?

5. Two kinds of expansion are possible:


RADIUS OF CURVATURE
RED SHIFT
VIOLET SHIFT
ETC.
TIME
BIG BANG

PULSATING FINITE UNIVERSE



HYPERBOLIC INFINITE UNIVERSE

Major Objection:	Elements beyond hydrogen are found in stars. Thus it seems more likely that elements are constantly being "cooked" in stars, not created in one perimeval explosion.

HE UNIVERSE - THE EARTH, ITS POSITION IN THE UNIVERSE

This brief reading reference is to start you thinking about the origin of the earth and the processes which were involved in its evolution.

Required Reading: Challenge of the Universe, 523 Hy, pages 21 & 23

The World We Live In, Volume I, pages 10 & 13
(Audio Tape - same title)

Recommended Reading: The World We Live In, Volume I, (574 9L72W VI), pages 14-24

A Short History of the Universe, pages 93-119

QUESTIONS FOR CONSIDERATION:

1. What is the position of the earth in the galaxy?

2. If the net effect of all the motions the earth goes through is to give it a speed of 685,000 miles per hour through space, why don't we on earth sense that we are moving?

3. Name the three main concentric spheres of the planet earth. Describe their make-up.

4. The Greek philosopher Heraclitus said, "This world was ever, is now, and ever shall be an ever-living fire". On the basis of your knowledge of the changes taking place in, on, and around the earth, would you agree with this statement?

5. If you do not agree with the statement in four, what changes taking place in the earth would prevent this earth from remaining an "ever-living fire"?

Four basic questions to be answered about the Solar System:

1. Why do the planets travel around the sun?

2. Why are the planets moving in the same direction?

3. Why are the four smaller inner planets made of heavy materials and why the four outer giants made of light materials?

4. How could the slow spinning sun have been the parent of planets that whirl about so swiftly?

THE EARTH, ITS POSITION IN THE UNIVERSE

I. The Origin of the Earth

   A. Cosmic Cloud Theory

   B. Double Star Theory

   C. Near Collision Theory

II. The Evolution of the Earth According to the Cosmic Cloud Theory

   A. Condensation of primordial gas and dust cloud by starlight and gravity within eddies.

   B. The evolution of protoplanets

   C. Thermonuclear fires begin in the sun.

   D. Formation of the planet - loss of gaseous shells

   E. Formation of the Core

   F. Continents congeal

   G. The "Coming of the Waters"

   H. The building and leveling of mountains

   I. The March of the Glaciers

III. Time Scale of the Earth's Evolution

A. From the Origin to the Present

B. The Destiny of the Earth

C. Methods of Age Determination

1. Salinity of the oceans.

2. Radioactive decay - Radiogenics.

3. Dating of meteorites.

IV. Present Earth

A. Core, Mantle, Bottom 3/4 of Crust - Geophysics and Seismology

B. Upper 1/4 of Crust - Geology

C. Biosphere - Biological Sciences

D. Atmosphere - Meteorology

E. Oceans - Oceanography

V. How does the Earth differ from the rest of the Universe?

A. State

B. Temperature

C. Kinds of Elements

D. Position in the universe

VI. Summary of Hypothesis on Solar System's Origin

A. It is assumed that the sun and its planets were formed within a cloud of cosmic dust. The earth possibly began as a relatively small mass and grew in size as its gravitational forces attracted more and more dust particles.

B. As the earth increased its mass, its gravitational forces also increased, squeezing the particles closer and closer together. As the particles became compressed, the temperature of the earth began to rise.

C. Eventually the earth started to cool, and continued cooling over many millions of years. During the process of heating and cooling many chemical materials were formed. The heavier materials sank to the center to form the core of the earth, and the lighter materials formed the outer portion.

D. As it cooled, the surface of the earth eventually solidified, except where volcanic eruptions poured molten rock out onto the surface. The original crust of the earth and even the waters of the ocean were largely the result of volcanic activity.

E. Because of its size, the earth exerted enough gravitational force to hold on to the gases that were swirling around it, which otherwise would have drifted out into space. The ancient gases were quite different from those in today's atmosphere.

Name ____________________

Science I ___ Hour ___

Date ____________________

Science I
Discussion Questions

THE UNIVERSE, THEORIES ABOUT THE ORIGIN OF THE SOLAR SYSTEM

1. Identify and discuss three different methods, requiring optical instruments, which may be used to measure distances between bodies in space.

2. What is meant by the statement, "Distance is relative not absolute?"

3. Identify 4 characteristics of the Milky Way Galaxy.

4. What is the "Cosmological Principle?"

5. Any Cosmological Theory that we may develop to account for the nature of the universe must account for the following:

   (a) The darkness of the night sky: that we are not drowned by a flood of light from the distant galaxies.

   (b) The red shift: that galaxies recede from us with speeds proportional to their distances away (Hubble's Law)

   (c) The "age of the universe" which is greater than 5,000 million years.

   (d) The homogeneous distribution of galaxies in space.

   What is meant by each of the factors listed above?

6. Discuss the fundamental differences between Evolutionary Theories and the Steady State Theory.

7. Define the following:
    (a) Light Year -

    (b) Universe -

    (c) Galaxy -

    (d) Near Cluster -

    (e) Super Nova -

    (f) Cepheid -

    (g) Cosmology -

    (h) Scientific Notation -

8. What is the predicted fate of the earth? On what basis can we predict this future for the earth?

9. What is a protoplanet? What part did it play in the evolution of the earth according to the Cosmic Cloud Theory ?

10. Explain the dating process based on the salinity of the ocean.

11. Which theory for the origin of the solar system would you choose to defend as explaining the facts as we know them today?

MAN'S EARLY CONCEPTS OF THE NATURE OF THE WORLD AND UNIVERSE

Our changing world is filled with questions. Ages before there were classrooms or sciences, men faced those questions and searched for answers. In council or tribal ceremony, they thought about the nature of the earth. Where had the earth come from, when and why? Of what substances was it made or had there been no substance at all before the earth came into being?

Without a storehouse of facts to help him, ancient man answered these questions with myths. The earth was an island heaped up in a river, a plain made by playful gods, a half ball being carried on the back of a giant turtle plowing its way through endless mudflats. For each myth there were many others, each contradicting all the rest.

We can laugh at such traditions and myths and at the strange ideas of early Greek thinkers; but such laughter is unfair, for the men who devised those odd notions were just as honest in their thoughts and deliberations as we are today.

Such is the process of science.

Required Reading: Story of Atomic Theory and Atomic Energy, The; J.G. Feinberg, 539.7 F2.9, pages 9-18

Recommended Reading: History of Physics, A; C.A. Reichen, 530.9 R35h (L), pages 9-36 (many pictures)

Historical Background of Chemistry, A; H.M. Leicester, 500 Le, pages 5-15

Short History of Science, A; 509 Sh 5, pages 1-41

Short History of Biology, A; I. Asimov, 574.09 As83s(L), pages 1-19

Enrichment Tapes: Galileo Passes a Crucial Test
Harvey and the Beating Heart
Herodotus Reports on His World
Leeuwenhoek Sees the Little Animals
Sun, Moon, and Stars (Kepler)
Newton, Fashions a New Tool
Lamp at Midnight

QUESTIONS FOR CONSIDERATION:

1. Considering deductive and inductive approaches to scientific investigation:
    a. Which of these describe the speculative Greek's approach to basic questions about matter and energy?
    b. Is there any evidence that scientists of the Greek Period utilized the experimental or research approach to science?
    c. Do speculation and debate have any role in modern-day approach to science?
2. What sort of conditions permitted many of Aristotle's views on science to become so authoritarian as to shut out scientific inquiry?
    a. Could this ever happen again that certain ideas could become so firmly entrenched as to become absolute or incapable of being changed?
3. What conditions prevailed to encourage a rebirth (renaissance) of inquiry in the 16th Century?
4. Should there be any restriction or limitation placed on scientific inquiry?

Science I

MAN'S EARLY CONCEPTS OF THE EARTH AND THE UNIVERSE

I. Man's Early Concepts of the Nature of the World and Universe

A. Prehistoric man (Man the Doer)

1. Period of trial, error and accident

2. Stone Age

B. Sumerian-Babylonian-Egyptian period (5000 B.C. - 500 B.C.)

1. Beginnings of:

a. Agriculture

b. Technology

c. Astronomy

d. Mathematics

e. Record keeping

2. Mysticism

C. Greek Period (500 B.C. - A.D. 500) Man the Doer becomes Man the Thinker

1. The Greek philosophers "think" about matter

a. Thales (water)

b. Anaximander (apeiron)

c. Anaximenes (air)

d. Heraklitos (fire)

e. Anaxagoras (on motion, energy?)

f. Empedocles (water, air, fire, earth)

g. Democritus ("atoms" and motion)

h. Pythagoras

2. Schools of Thought (philosophy, mathematics and medicine)
    a. Platonic
    b. Aristotelian
    c. Ptolemaic
    d. Aesculapian
    e. Hippocratian
    f. Galenic

3. Roman Contributions to Science

II. Middle Ages (500-1500)

1. Theology and Science
2. Arab Influence (Moslem Empire)
3. Alchemy
4. Dante's World and Universe

III. Beginnings of Change

- A. Why change?
- B. Areas of Change
    1. Art and Literature
    2. Great Explorers
    3. Science
    4. Paper Making
    5. Printing Press

IV. Rebirth of Science

- A. 1500-1700
    1. "De Humani Corporis Fabrica" - Andrea Vesalius
    2. "De Revolutionibus Orbium Caelestium" (On the Revolutions of the Heavenly Spheres) - Copernicus

MAN AND SCIENCE IN THE CHANGING UNIVERSE

We have seen that man and earth are not the focal point about which the rest of the universe revolves. At the same time, we recognize that man, as a part of the total universe, is quite unique.

Perhaps the most unique characteristic of man is his ability to think. It is because of this capacity, inborn to various degrees in all men, that mankind has been able to relate to the world in which he lives.

The thinking man does not "simply exist" as a living organism in the world for a short period of time and then just cease to exist. The thinking man has an awareness about the universe and his relationship to it. He is curious, he questions, he searches for understanding, he is aware of his relationship to other living organisms, he looks for a purpose to life, and finding it, seeks fulfillment. The result of this human enterprise is that man does not simply exist for a time, as a part of a changing universe. Rather, he represents a force capable of influencing the changes which take place in it. Idealistically he seeks to influence change for the good of mankind.

By what process does this come about? How does man come to understand himself? How does man learn that he is a part of something else and that this "something" affects him in many ways?

As we think about these questions it might be interesting to make a comparison between the learning experiences of a very young baby and those of ancient man. Ancient man, even as an adult, probably didn't understand much more about himself or his relationship to the universe in which he lived than a baby of today understands after six months of life. Both the ancient man and the baby had the ability to learn new things. For both, the learning experiences were largely a result of "trial and error", a case of learning by personal experience and frequently, quite by accident.

The ancient man, in his entire life time of experience never got very much beyond this stage. His lifetime was a continual struggle for survival. He learned to do what was necessary to stay alive or he perished. He was probably just as curious about the world in which he lived as our baby of this century, but for ancient man, his personal experience was his only teacher!

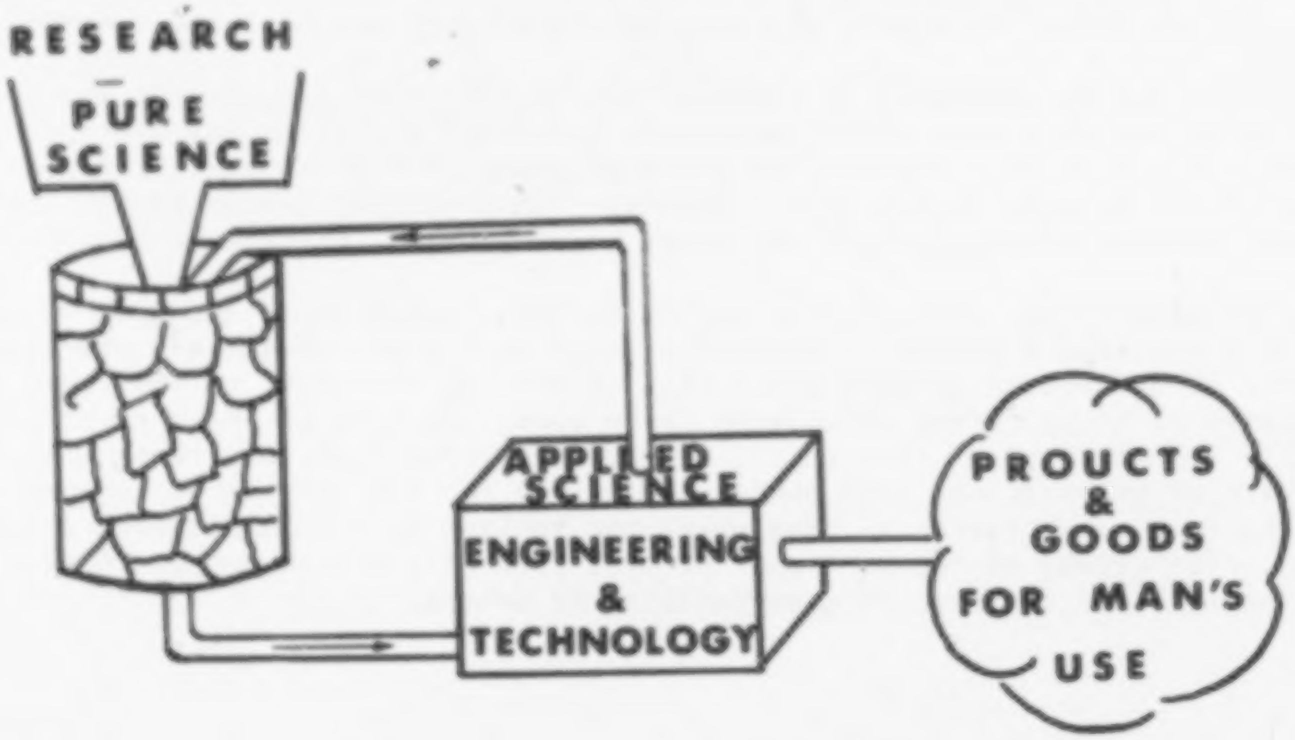
It is not unreasonable to suspect that 50,000 years ago, in the early Stone Age, there may have been individuals with potential abilities for abstract thinking or creative expression on par with those of Shakespeare, Beethoven, or Einstein of the more recent past. However, the potential genius of the Stone Age Man was not stimulated, to any great degree, by the experience of others.

The generations upon generations which have passed since the time of ancient man have provided a legacy of knowledge based on the experience and creative thought of succeeding generations. Each generation transmits to the next, knowledge of those things considered to be good, the best of their culture. It is this "common fund of knowledge", accumulated through the experiences of the intervening generations, that makes it possible for the baby in our comparison to relate to his universe in ways which the ancient man could not even dream about. The dreams of today become the realities of tomorrow and these realities are the seed bed of ideas for generations yet unborn.

Science has contributed much to the common fund of knowledge. As early as 600 BC the Greek culture was influenced by the classic theorist of that period. However, the Greek scholars and other classical thinkers of that era never considered the need or importance of testing their theories by experiment. As a result, its influence never became much more than an adventure of the mind.

The period of transition from science, as pure conjecture in the minds of men, to science as process and product, which we know today, was a long and difficult one. It is only in recent years that science has become a respected contributor to the fund of common knowledge and that scientists have been regarded as more than "egg heads," dreamers who fretted away their time on useless ideas. This general attitude was reflected in the opening remarks of General Leslie R. Groves in 1943, as he welcomed the staff of scientists who were called to Los Alamos to work on the atomic bomb project during World War II. He said, "At great expense we have gathered here the largest collection of crackpots ever seen."

The new age of science has barely dawned and already we live in a world of reality which 20 years ago would have read like science fiction. Within the last two decades, the process of science has radically transformed the policies of nations and the personal lives of people everywhere. The spectacular achievements of the past few years have made the words "science" and "scientist" very familiar and respected and yet, few persons really understand what science is or its role for the future of mankind. As we begin our formal study in science, we shall consider what science is and what it is not. We will take a close look at the "process of science" and point out the difference between science and technology. Finally we shall look at science from the point of view of the scientist and the non-scientist. The importance of our discussions relative to these points must not be minimized for the ideas and attitudes that you form with reference to them will have a great deal to do with your ability to understand yourself and your relationship to the world in which you live.



Science IA

Resource Materials

MAN AND SCIENCE IN THE CHANGING UNIVERSE

When scientists probe the nature of energy or the structure of the universe, what is their motivation? What is the ultimate purpose of science? This latter question has challenged some of the most profound scholars of the past. It is of increasing concern today, not only to professional scientists, but to nonscientists as well.

Required Reading: An Introduction to Science, George W. Beadle, Listen to Leaders in Science, pages 3-14, 506.9 L89L (L)

Recommended Reading: "Careers in Science", Warren Weaver, V.P. Sloan Foundation, Listen to Leaders in Science, pages 266-278

"Preparation for a Lifetime in Science", Lee A. DuBridge, Listen to Leaders in Science, pages 17-25

Audio Tape: Same title as required reading.

QUESTIONS FOR CONSIDERATION

1. What is science?

2. What is meant by "the process of science"? Discuss the difference between science as process and scientific knowledge.

3. What is the ultimate purpose of science?

4. Does science have limitations? Be prepared to discuss various issues in support of your point of view.

5. Why is it important that all persons, not just scientists, understand science?

MAN AND SCIENCE IN THE CHANGING UNIVERSE

I. What Science Is And Is Not

   A. What is science?

   B. Common misconceptions of what science is

II. The Process Of Science

   A. The approach

   B. Personal attitudes necessary in the "process of science"

   C. The difference between the process and product of science

III. Science And The Scientist

   A. Who is a scientist?

   B. "Pure science," its purpose

What Is Science?

What is Science? We have found that people have many different ideas as to what science is. The ten statements which follow are definitions of science which have been collected from various sources. Read each statement carefully. Think about the statement in terms of your own understanding of what science is and then rate each statement.

If you feel that the statement is a very good definition for science give it a rating of 4. If you think it is a very poor definition rate it 0. Give each of the statements a value ranging from 0 to 4.

RATING

_______ 1) Science is KNOWLEDGE. Science is the knowledge about man and everything in his environment which has been collected and classified by men since the time of the earliest scientists up to the present.

_______ 2) Science is FORCE. Science is a force which can invade, possess, cause change and in various ways influence the future of man. It is these different kinds of forces which exist in nature that we call science.

_______ 3) Science is STUDY. Science is the study of certain subjects which deal with special kinds of knowledge like Science I or Chemistry or Physics or Biology, Astronomy and many others.

_______ 4) Science is NATURE. Science is really everything that there is in nature. Even though we might not understand certain things in nature they are still what science is.

_______ 5) Science is THEORY. When man studies nature he discovers certain things which are then used to set up different theories or laws. These theories and laws are what science is.

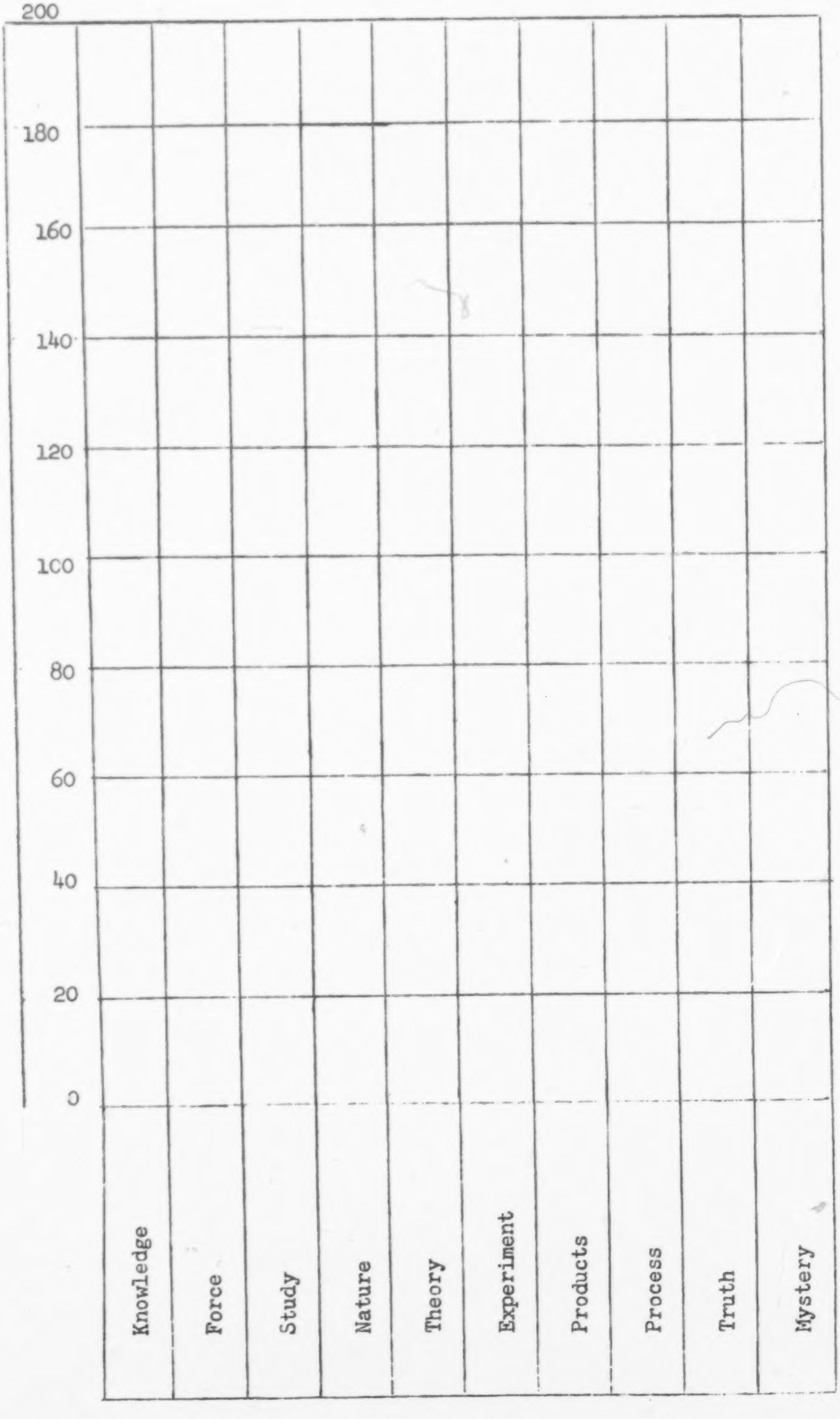
_______ 6) Science is EXPERIMENT. Science is experimenting. When you go into the lab and try different things to see what happens, this is science.

_______ 7) Science is PRODUCTS. After man discovers certain theories and laws he puts them to work to make things which are of benefit to man and other things. When man is making things like new drugs, rocket fuels or stronger plastics and things like this, that is science.

_______ 8) Science is PROCESS. Science is a process by which one gains knowledge about himself and his environment.

_______ 9) Science is TRUTH. There are certain things in nature which are true. We don't know what all these things are but the truth we do know is science. Not all truth is known but more is discovered every day. This is why science grows.

_______ 10) Science is MYSTERY. There are a lot of things about nature that we understand. We call this knowledge. The part of nature which is still a mystery to us is what we call science.


200
180
160
140
120
100
80
60
40
20
0
Knowledge
Force
Study
Nature
Theory
Experiment
Products
Process
Truth
Mystery

IV. Science and Technology

A. The difference between science and technology

B. Science and Engineering

C. The need for Scientists and Technologists

V. Science and the Non-scientist

A. The accomplishments of science and their significance for the citizen.

B. The goals of science in general education.

C. The goals of the integrated, concept centered, science program.

Science I

Review

A. BASIC QUESTIONS ABOUT THE UNIVERSE

I. The Solar System
  - Position of Planet Earth
  - Relative Motion of the Planets
  - Light Year, Unit of Distance
  - Position of the Solar System in the Milky Way

II. Methods of Measuring Distance in Space
  - Optical Methods
    - Parallax
    - Brightness (Cepheids, Absolute & Apparent Brightness)
    - Red Shift (Doppler Effect and Hubble's Law)
  - Radio Methods

III. Galaxies and the Universe
  - Milky Way (Size, Shape, Number of Stars, Location of Sun, Closest Stars)
  - Types of Galaxies
  - Other Galaxies
  - Clusters (Local Group)

IV. Astronomical Instruments
  - Light Telescopes (Refracting, Reflecting)
  - Radio Telescopes
  - Spectrometers

V. Cosmology
  - Cosmological Principle
  - Present Theories About the Nature of the Universe
    - Steady State
    - Evolutionary
  - Summation of Current Ideas in Cosmology
  - Fundamental Questions, as yet Unanswered

B. THE EARTH, ITS POSITION IN THE UNIVERSE

I. Theories as to Origin
  - Cosmic Cloud (Summation of Basic Ideas - p. 20)
  - Double Star
  - Collision

II. Evolution of the Earth (Cosmic Cloud)
  - Methods of Determining Age (four)
  - The Probable Destiny of the Earth (Evolution of Stars)

III. The Uniqueness of the Earth in the Universe

C. MAN'S EARLY CONCEPTS OF THE EARTH AND THE UNIVERSE

I. Early Concepts About the Nature of the World and Universe
  - Prehistoric Man
  - Greek Influence (Empedocles, Democritus, Pythagoras, Aristotle, Plato, Galen)

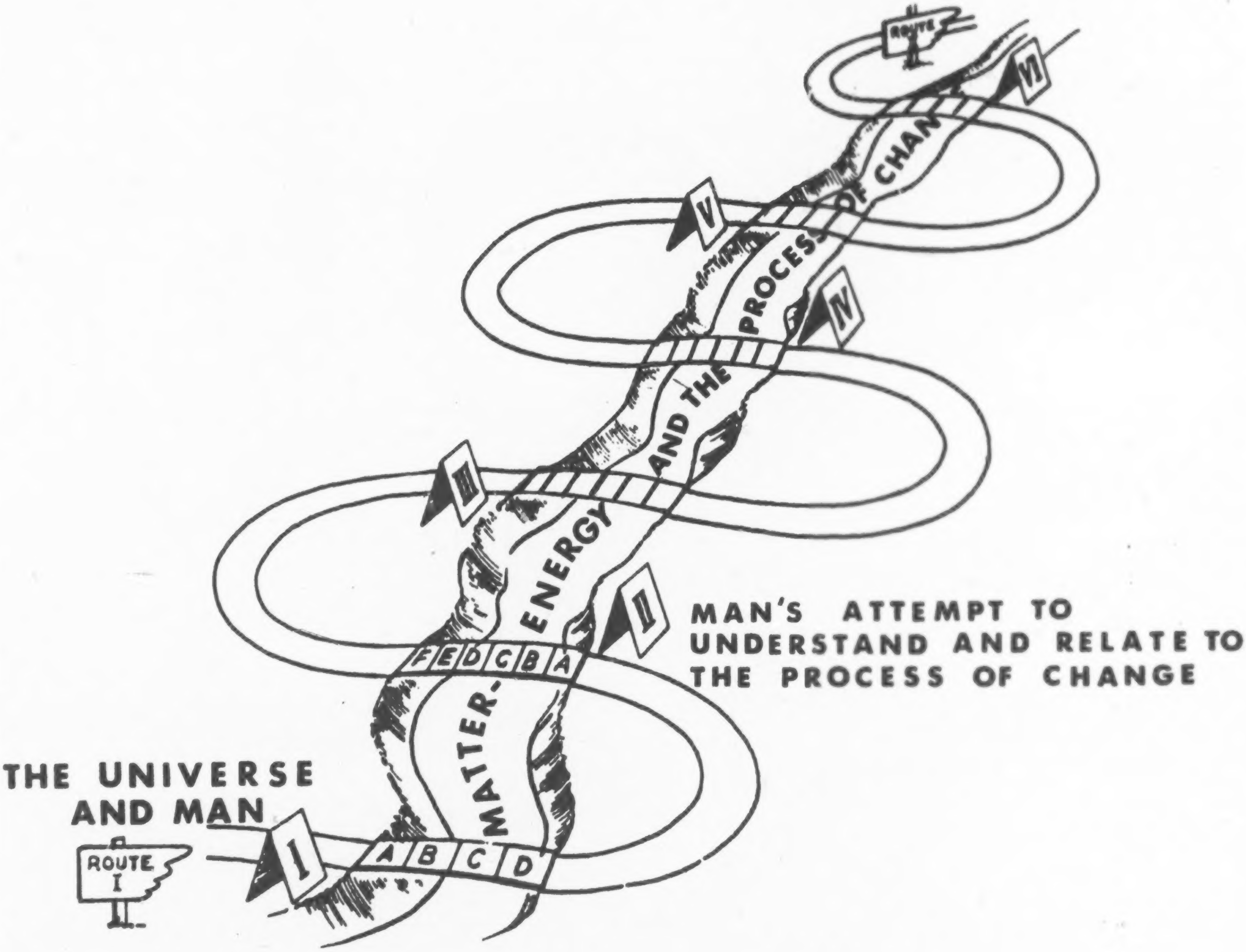
II. Middle Ages (500-1500)
  - Compatibility of science and religion, 500-1500
  - Dante's world
  - Significant changes during the renaissance

III. Rebirth of Science (1500-1700)
  - Andrea Vesalius
  - Copernicus
  - Other Notables

D. MAN AND SCIENCE IN THE CHANGING UNIVERSE

I. What Science Is and Is Not
  - Science and Technology (Process and Products)
  - Scientific Methods
  - Personal Attitudes and the Process of Science

II. Science and the Non-Scientist
  - Ways in which Science has Influenced Society
  - Purpose of Science Education


ROUTE
VI
V
IV
III
II
MATTER-ENERGY AND THE PROCESS OF CHAN
F E D C B A
MAN'S ATTEMPT TO UNDERSTAND AND RELATE TO THE PROCESS OF CHANGE
THE UNIVERSE AND MAN
ROUTE I
I
A B C D

II. MAN'S ATTEMPTS TO UNDERSTAND AND RELATE TO THE PROCESS OF CHANGE.

A. Sensory Experience, Knowledge and the Process of Science

B. The Need for Quantitative Descriptions

C. Understanding Through Graphic Representation

Science IA
Resource Material

MAN ATTEMPTS TO UNDERSTAND AND RELATE TO THE CHANGING UNIVERSE

Awareness and the senses: All living things are equipped with mechanisms that enable them to react to their environment.

Required Reading: The Science of Science, 501 W525 (L), Only Human, pages 75-77

Science and Human Life, 501 B985 (L), First Steps in Knowledge, pages 79-86

Recommended Reading: "The Zero Sense", Science World, Sept. 30, 1965

Science and Human Life, Imagination in Human Life

QUESTIONS FOR CONSIDERATION:

1. Why do you suppose that all living organisms have sense mechanisms? Do you believe that it would be possible for any organism to survive in its environment with "zero" sense mechanisms? Explain.
2. Discuss the limitations of human sense mechanisms? What implications does this have for science?
3. Both man and animals react to their environment via similar sense mechanisms. In terms of this similarity what makes man distinct from animals?
4. What is the basic difference between the words which we use to describe the objects one finds within his environment and the words which describe ones sensory experience with these objects? As one specific example to illustrate this point, what is the basic difference between the words magnet and magnetism?
5. "The fleeting world of today is enshrined in a timeless world of words in which all our yesterdays can live." Discuss this quotation in terms of the relationship between knowledge and sensory experience?
6. What do sensory experiences have to do with man's creative thought?

I. Awareness And The Senses

A. By what means does man become aware of changes within his environment?

1.

2.

3.

4.

5.

B. How does man classify his sensory experiences?

1.

2.

C. The relationship between the sense mechanisms and sensory experience

1. What is the fundamental difference between the sense mechanism and sensory experience?

2. Could an individual, born without any of the five sense mechanisms survive?

II. The Use Of Words To Describe Sensory Experiences

A. Can the sensory experience of one person be described in such a way as to give another person the same experience?

B. Can all sense experiences be defined?

III. Knowledge, Sensory Experience, And The "Process Of Science"

A. What is knowledge?

B. Does an individual possess knowledge at birth?

C. How does one acquire knowledge?

1.

2.

3.

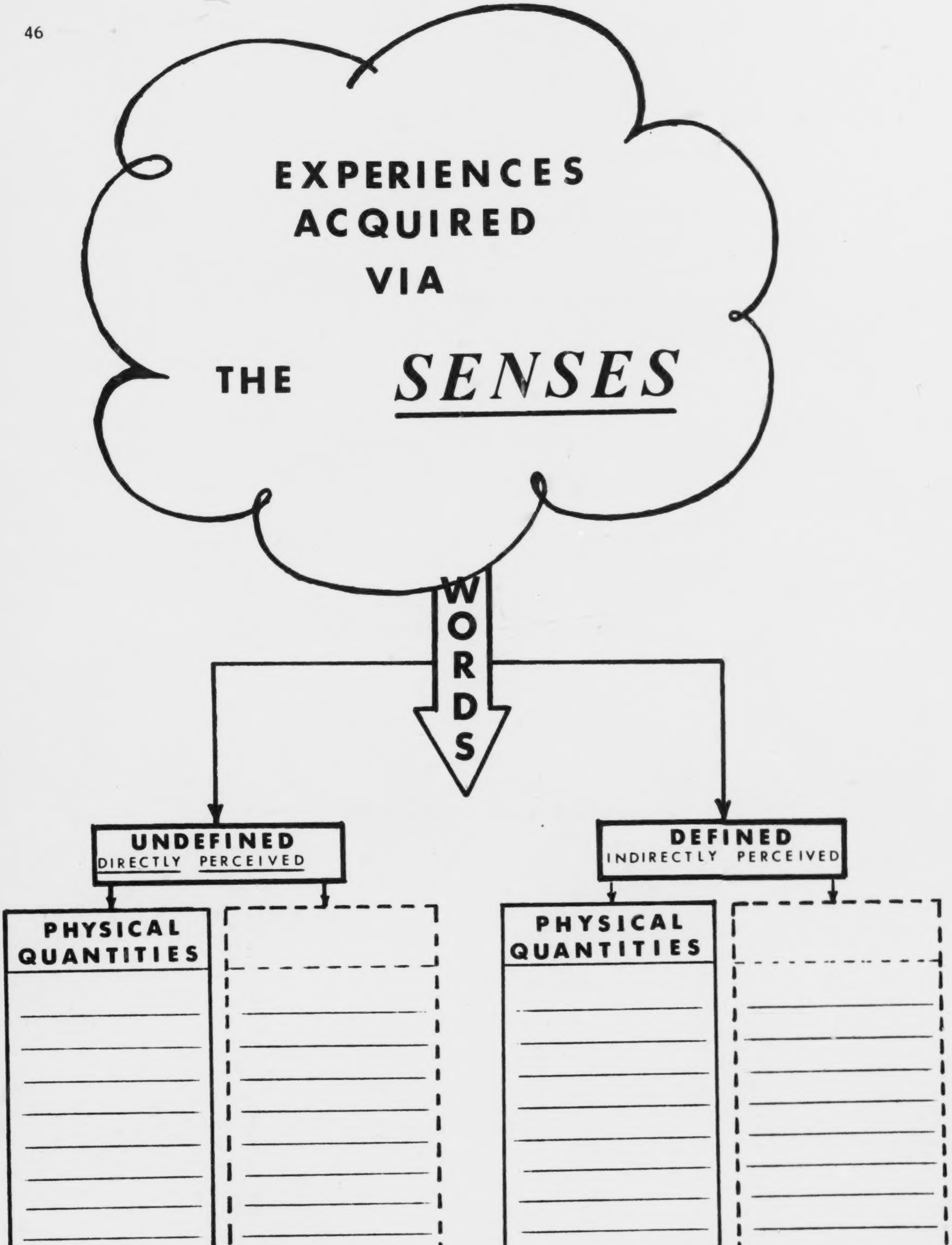
4.

5.

6.

a. Advantages of these methods

b. Disadvantages of these methods


EXPERIENCES ACQUIRED VIA THE SENSES
WORDS
UNDEFINED
DIRECTLY PERCEIVED
DEFINED
INDIRECTLY PERCEIVED
PHYSICAL QUANTITIES
PHYSICAL QUANTITIES

IV. Sensory Experience And Physical Quantities

A. What is a physical quantity?

B. Can all physical quantities be defined?

C. Under what conditions can a physical quantity be defined?

V. The Use Of The Senses In The Process Of Science

A. Under what conditions may the senses be used to make quantitative measurements?

B. How reliable are the values determined by sensory experience?

C. Can all physical quantities be measured?

D. What conditions must be implied by the words used to represent physical quantities?

1.

2.

3.

4.

Physical Quantity	Symbol	Definition	Vector	Scalar	Gravitational System		
					F.P.S.	C.G.S.	M.K.S.
length	l	undefined	x		ft	cm	m
force	F	undefined	x		lb	g	Kg
time	t	undefined		x	sec	sec	sec

Summary of Ideas

1. Knowledge is the sun total of man's understanding of the nature of the universe.

2. We are born into the world without knowledge but each of us is born with the capacity to learn.

3. Each of us has the responsibility to use our capacity to learn in order to become useful citizens in a world society.

4. The opportunity to learn comes about as a result of the experiences we have and our ability to detect these experiences through our senses: we see, hear, taste, touch and smell.

5. Knowledge is gained only when we are able to interpret and understand the significance of the experiences detected by these senses.

6. In order to communicate with others, in the process of interpreting observed sensory experiences, it becomes necessary to use symbols (written or spoken words) to describe the experience detected through the senses.

7. Words used to describe sense experiences, which can be measured, are called Physical Quantities.

8. Words used to describe experiences directly observed by the senses cannot be defined. Those which can be measured are "Undefined Physical Quantities".

9. Words used to describe experiences which can be measured but not directly observed by the senses are Defined Physical Quantities.

THE NEED FOR QUANTITATIVE DESCRIPTION

As we attempt to interpret and describe experiences detected by the senses with greater meaning we find that it is necessary to talk about the experience in terms of physical quantities that have number values attached to them. The numbers suggest "size" or "degree" which help us communicate ideas more meaningfully to others.

A description which has numerical values attached to it is called a Quantitative Description. It is not possible to investigate any product or process of change in much detail without making quantitative measurements relative to it.

Since earliest times man has developed many different systems of measurement and tools by which measurements could be made. Over the years both the systems of measurement and measuring instruments have been greatly improved. Today precise measurement and accurate quantitative descriptions of the properties of matter and energy are an essential part of the process of science.

As we begin to take a closer look at some of the processes of change that effect our lives we will need to develop the ability to think quantitatively. We will need to become familiar with measuring systems and develop skill in the use of many different types of measuring devices. We will make many quantitative measurements, some very very small, others very large. We will need to know how to represent number values in such a way that they become meaningful to us individually and also communicate precisely the same meaning to others.

Laboratory Problem

MEASUREMENT STANDARDS

INTRODUCTION:

In our previous work we have seen that any system of measurement is based on arbitrary standards. The length of string became our standard for linear measure on one occasion. We found that although the string has its shortcomings it did serve as an adequate standard for our purposes. The metric ruler with its subdivisions based on tens of units is a more accurate and usable measuring instrument than the lengths of string in the determination of the surface dimensions of various objects. In this laboratory problem you will use a scale, graduated with subdivisions of tens, to make quantitative descriptions of various special properties of matter.

PROBLEM:

Using a graduated scale as your sole measuring device produce a useful standard which can be used to measure both the volume and weight of other objects.

PROCEDURE:

A. You will be given a square shaped piece of standard paper and a uniformly graduated scale.

    1. Assign a name to the units of length represented on the scale.
    2. What is the total length of the scale, in terms of these units?
    3. Use the graduated scale to determine the area of the square shaped standard paper.

B. Determine the volume of this square shaped piece of paper.

    1. What problem must you immediately resolve?
    2. What can you do to resolve this problem?
    3. What is the volume of the standard paper? Be sure to give both the numerical value and the units.
    4. Can the volume of this sample of standard paper be used as a standard of volume?
    5. Select a name to represent a volume equal to the volume of the standard paper.
    6. What number relationship exists between the unit of volume equal to the volume of the standard paper and the value of one unit length on the graduated scale?
    7. What advantage does a volume--length relationship of this sort provide for a measuring system?

C. Your teacher will provide you with a numbered sample of paper. This sample and the square sheet of standard paper used in part B have the same thickness. Use the volume standard you established in part B to determine the volume of the numbered sample.

D. Your teacher will provide you with a numbered sample of paper which is wadded up. The wad is composed of paper which has the same thickness as the paper used in parts B and C. Your problem in part D is to use the standard to determine the weight of the paper wad. Use the square sheet of paper provided in part A as a reference standard for measuring weight.

Laboratory Problem Report

Name ____________________

Science I Hour _____

Date ____________________

MEASUREMENT STANDARDS

A. 1. What name was assigned to the unit of length represented on the scale?

____

2. The length of the scale, in these units equals ____________________.

3. The area of the square sample of standard paper ____________________.

B. 1. What problem must you immediately resolve before the volume of the standard paper can be determined?

____

2. What procedure was used to resolve the problem? ____________________

____

3. What is the volume of the standard paper? ________________________.

4. Can the volume of the standard paper be used as a standard of volume?

____

5. What new name did you give this unit for volume? ____________________

6. What number relationship exists between this new standard for volume and our standard for length?

____

7. What importance does this have in the devising of a system of measurement?

____

C. What is the number of the paper sample assigned to you? ________________

What is the volume of the paper sample assigned to you? ________________

D. What is the number of the paper wad assigned to you? ________________

1. What name did you give the standard paper to represent units for weight?

____

2. Could this measuring standard be used to measure weight anywhere?

____

3. What is the weight of the paper wad (in weight units of your choice)?

____

4. What is the numerical relationship between the unit you assigned for the volume of the paper wad and the unit you assigned for the weight of the wad?

____

5. Why do you think that a simple relationship between volume and weight units is important in the design of a good measuring system?

____

Problem Assignment

Name ______________________________

Science IA Hour ______

Date ______________________________

THE METRIC SYSTEM - 1

Units of Measurement

length - meter(m)
weight - gram (g)
capacity (volume) - liter(l)

Conversion Factors

$1\ ml = 1\ cc = 1\ cm^3$
$1\ cm^3$ of H_2O at $4^oC = 1\ g$

Metric Unit Prefixes

micro	-	.000001	(μ)
milli	-	.001	(m)
centi	-	.01	(c)
deci	-	.1	(d)
UNITY	-	1.0	
deka	-	10.0	(dk)
hecto	-	100.0	(h)
kilo	-	1000.0	(k)

1. Convert each of the following quantities to the required smaller unit.

a. 15 meters = ______ dm
b. 14.7 centimeters = ______ mm
c. 2.3 kilograms = ______ g
d. 6.576 grams = ______ mg
e. 62.5 dekaliters = ______ l
f. 9.37 liters = ______ ml
g. 1.25 kilograms = ______ dg
h. 62.54 centigrams = ______ mg
i. 0.23 kilometer = ______ μ
j. 0.034 kilogram = ______ mg

2. Convert each of the following quantities to the required larger unit.

a. 937 decimeters = ______ m
b. 125 milliliters = ______ l
c. 2.3 millimeters = ______ cm
d. 6.576 grams = ______ dkg
e. 62.5 grams = ______ kg
f. 627 milligrams = ______ kg
g. 867 centimeters = ______ km
h. 489 milligrams = ______ g
i. 0.23 milliliter = ______ cl
j. 5.178 milliliter = ______ kl

3. Add 340 mg., 90 cg., and .00564 kg. Express the answer in grams.

4. A cubic box contains 1,000,000 grams of water.
   a. What is its volume in milliliters? ________________ ml
   b. What is its volume in cubic centimeters? ________________ cc
   c. What is the length on one side in cm.? ________________ cm
   d. What is the length of one side in meters? ________________ m

5. A one liter graduate has a diameter of five centimeters. There is a four centimeter ungraduated portion at the top. How tall is the cylinder?

____

USING THE COMPOUND MICROSCOPE

The microscope is an instrument especially designed for the study of objects too small to be seen and examined with the unaided eye. Your microscope will act as an extended sense of sight, reaching down into a new world--the world of the very small--to reveal what is otherwise invisible.

The purpose of this exercise is to introduce you to the compound microscope and to give you practice in its use.

MATERIALS (Parts A, B, C, and E)

Compound Microscope
Lens paper
Several standard glass microscope slides
Round or square cover glasses
Soft cloth free of loose fibers
Medicine dropper (pipette)
Nylon or other cloth
Dissecting needle
Fibers of cotton, wool, and human hair
Fine-print newspaper containing the letter "e"
Tumbler of water
Plastic ruler marked in mm.
Filamentous algae

PROCEDURE

Part A: SETTING UP THE MICROSCOPE

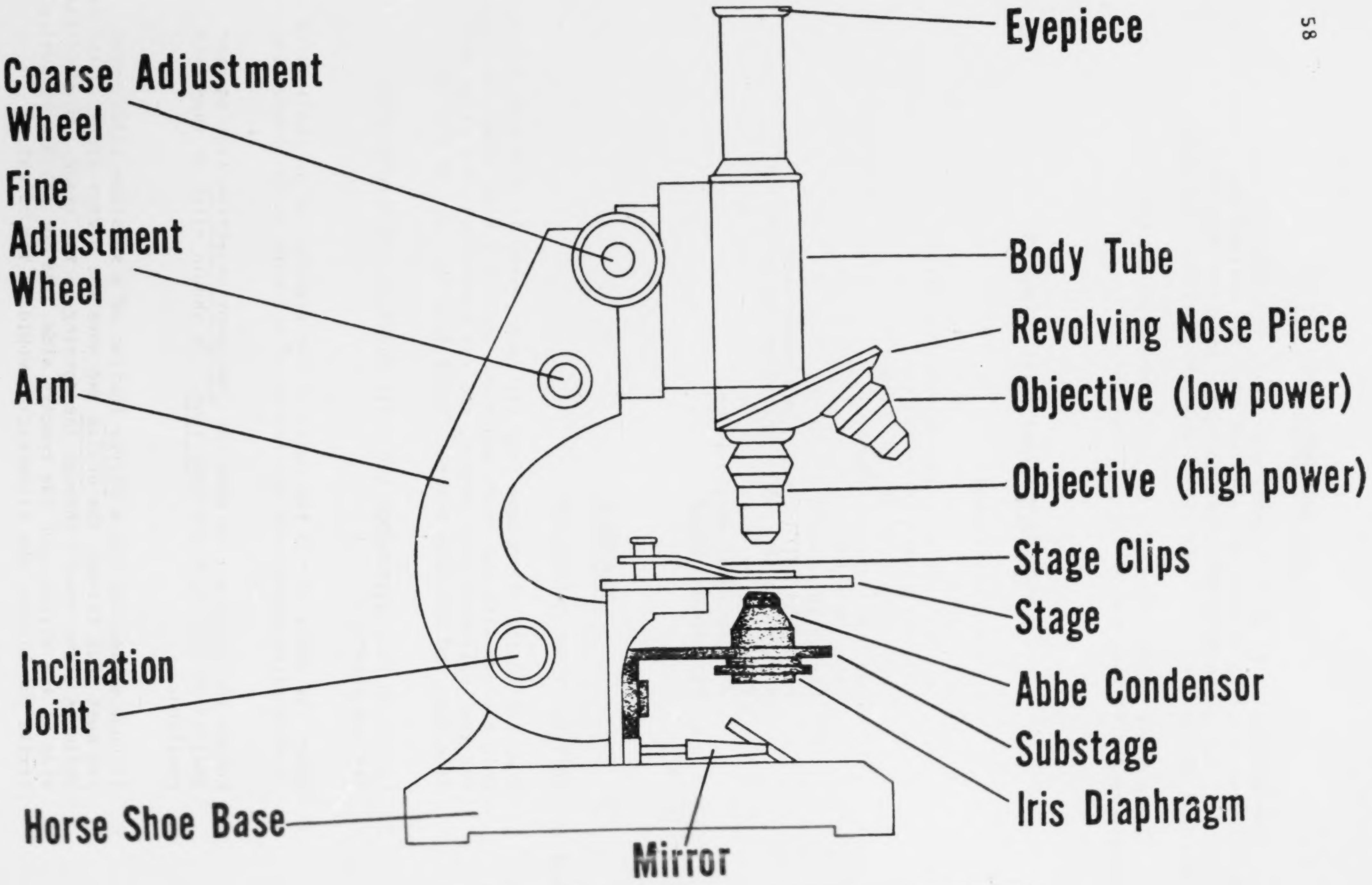
1. When taking the microscope from its case, carry it with both hands. Hold the arm with one hand, and place the other hand under the base. Set the instrument down gently, the arm toward you, the stage away from you, and the base several inches from the edge of the table.

2. Locate on your microscope the parts shown on the accompanying diagram sheet.

3. Learn the names of all the parts in the drawing, as we shall refer to them often throughout the course of our work in the laboratory.

4. Rotate the nosepiece so that the low-power objective (the shorter one) is in line with the body tube. It should click or snap into position.

5. If your microscope has a mirror instead of a substage illuminator, you must look through the ocular and move the mirror around until it reflects light upward through the opening in the stage. Use the flat side of the mirror, not the concave side. Do not let direct sunlight strike the mirror; the illumination would be too bright.


Eyepiece
Coarse Adjustment Wheel
Fine Adjustment Wheel
Body Tube
Revolving Nose Piece
Objective (low power)
Arm
Objective (high power)
Stage Clips
Stage
Abbe Condensor
Inclination Joint
Substage
Iris Diaphragm
Horse Shoe Base
Mirror

Huygenian Eyepiece	Objectives		Total Magnification	Working Distance	Field of View
	Magnification	Numerical Aperture (N.A.)			
10×	4.0×	0.10	40×	28.3mm	3.85mm
10×	10.0×	0.25	100×	6.3mm	1.5mm
10×	43.0×	0.55	430×	0.4mm	0.35mm
[illegible]	97.0×	1.3[illegible]	970×	[illegible]mm	[illegible]15mm

6. Still looking through the ocular of the microscope, adjust the mirror, if any, and the diaphragm (by its arm or diaphragm disk) so that the round field of view is evenly illuminated, without glare.

   In those microscopes which are provided with a condenser, the diaphragm is a part of the condenser. The condenser is a device whereby the light can be critically focused on the specimen on the stage.

7. If the ocular or objective is cloudy or dusty, wipe the lenses gently in one direction with a piece of lens paper. Do not use any other kind of paper or cloth. Use a piece of lens paper only once.

Part B: HOW TO PREPARE MATERIALS

Materials to be studied under the microscope are placed on a standard glass microscope slide. Generally the material on the slide is covered with a thin round or square piece of glass or plastic usually called a cover glass. Both slide and cover glass should be as clean as possible.

Slides and cover glasses should always be held by their edges. Clean the glass slide with water, while holding the slide by its edges with your fingers. Wipe clean and dry with a soft cloth free of loose fibers or lint. A cover glass is fragile! Handle with care! Clean both sides of the cover glass simultaneously, using the soft cloth and being careful not to touch the surfaces of the glass with your fingers.

Cut or tear a piece of newspaper bearing fine print on which the small letter "e" appears, into a piece about 1 cm across.

Place this piece of newspaper on the center of the slide, with the letter "e" right side up.

With a medicine dropper or pipette put one drop of water on the piece of paper.

After waiting a few moments to allow the water to soak into the paper, put the cover glass over the paper. It requires some skill to place the cover glass on the slide so that no air bubbles are produced. The best method is to hold the cover glass at approximately a 45° angle to the slide and gently lower it with a dissecting needle until it covers the water. Bubbles may be removed by a gentle tap on the cover glass with the eraser end of a pencil. You have now prepared a wet mount, or water mount, of the piece of paper.

Part C: HOW TO FOCUS THE MICROSCOPE

1. Place the slide you have prepared on the stage of the microscope so that the paper is centered above the opening in the stage.

2. While looking at the microscope from one side, use the coarse adjustment to lower the body tube until the low-power objective almost touches the cover glass or until the stop is reached that prevents the objective from being lowered any farther. Never lower the body tube while looking through the eyepiece - you may accidentally ram the objective into the slide, breaking it and damaging the very expensive lens of the objective.

3. While looking through the ocular try to keep both eyes open. This will be difficult at first, but you can soon learn to ignore what is seen by the eye not looking through the microscope. Squinting and closing one eye tends to produce eyestrain. Learn to apply the left eye to the microscope if you are right-handed. This makes it easier to draw as you look through the microscope.

4. While looking through the ocular, use the coarse adjustment to raise the body tube until the printed letter comes into view. With the fine adjustment, make the focus as sharp as possible. What is the position of the letter "e" as seen through the microscope?

   Now move the slide on the stage from right to left. Which way does the image move? Move the slide away from you. Which way does the image move?

   Prepare another wet mount as directed in Part B above, this time using a small piece of nylon (or other) cloth. Observe the cloth under low power, again following the same steps in focusing above.

   Now observe the cloth under high power as follows. Move the object on the slide to the center of the field. Unless your instructor tells you that your microscope is parfocal, first raise the body tube and then change from the low power objective to the high power one. This must always be the procedure when using microscopes that are not parfocal. (With parfocal microscopes both the low and high power objectives are adjusted to the same focus, so you may simply switch from low power to high power without raising the tube.) Repeat the second and third steps in focusing. Be sure that the high power objective does not touch the slide. Never turn the coarse adjustment to move the high power objective downwards; use only the fine adjustment - and be sure to use it cautiously!

   Does the change from low to high power change the position of the image in the field of view? Does the field of view show a larger or smaller area of the object? Is the brightness of the field greater or less than with low power? Adjust the diaphragm to restore an even illumination without glare.

   The cloth is thicker than the paper with the letter "e", so you must rotate the fine adjustment knob back and forth slowly to see the fibers at different depths. Thus you can get a three dimensional picture of the cloth: length, width, and also depth. If time permits, you will also find it interesting to look at fibers of cotton, wool, and human hair.

Part D: CARE OF THE MICROSCOPE

The microscope, being an expensive instrument, must be given care. Again, it should always be carried by the arm and in an upright position with one hand under the base. When placed on the table it should be several inches from the edge in order to prevent an accidental fall to the floor. Avoid tilting the instrument at the inclination joint unless absolutely necessary because of your height. If the microscope is tilted and if you are using a temporary slide made with a drop of water the material and water may run off the slide. However, if it is necessary to use it in a tilted position, never leave it tilted when not in use, as the instrument is not well balanced then. Before and after use, the lenses should be cleaned with lens paper. Do not use any other material for cleaning lenses, as the optical glass is soft and easily scratched.

At the end of a laboratory period turn the low power objective into position and adjust it approximately one centimeter (about half an inch) above the stage. If the microscope has been tilted, restore it to the upright position. Be sure the stage clips do not extend beyond the stage. Return the microscope to the proper storage place. Always clean all slides and cover glasses which you have used.

Part E: USING THE MICROSCOPE TO MEASURE DISTANCE.

Introduction

The theoretical magnification of a microscope is the product of the magnification of the ocular lens and the objective lens of the instrument. Your microscope has an ocular lens of 10X and a low power objective of 10X. The total theoretical magnification of the instrument, on low power, is 100X. An object viewed in the microscope would appear to be 100 times larger than it looks to the naked eye at the same distance.

The high power objective of your microscope is 44X. This means that the total magnification of the instrument, on "high power", should be 440X or 4.4 times greater than on "low power."

Although one can calculate the total magnification of a microscope this "X" number does not allow us to determine the size of an object in the field of view unless there is a reference scale of some kind also visible in the field of view.

Our microscopes are equipped with metal "micron disc". This disc is placed between the two lenses of the ocular. The micron disc provides a constant reference scale which is always visible in the field of view. The actual distance between the "teeth" of the disc can be measured by use of a slide which is calibrated in microns. Such a slide is called a "stage micrometer". It has lines etched into the glass that are precisely 10μ apart.

Stage micrometers are very expensive and obviously cannot be used at the time a specimen is being viewed in the microscope. The "stage micrometer" is therefore used to calibrate the micron disc, that is to measure the distance between the teeth of the disc. Once this has been done you have a reference standard for length always present in the field of view for the microscope.

Procedure

1. With the low power objective in place measure the distance between the teeth of the micron disc.

2. Switch to the high power objective and measure the distance between the teeth of the micron disc.

3. With the low power objective in position place a plastic mm scale on the stage of the microscope so that its edge is directly across the center of the field of view. Measure and record the diameter of the field of view in mm. Convert this distance to μ.

4. Switch to the high power objective and measure the diameter of the field of view on high power.

The size of an object in the field of view can be determined directly by using the micron disc or indirectly by comparing the size of the object to the diameter of the field of view. In both cases it is necessary to know which objective lens is in position.

Part F: TECHNIQUES FOR REPORTING OBSERVATIONS IN MICROSCOPIC WORK

Introduction:

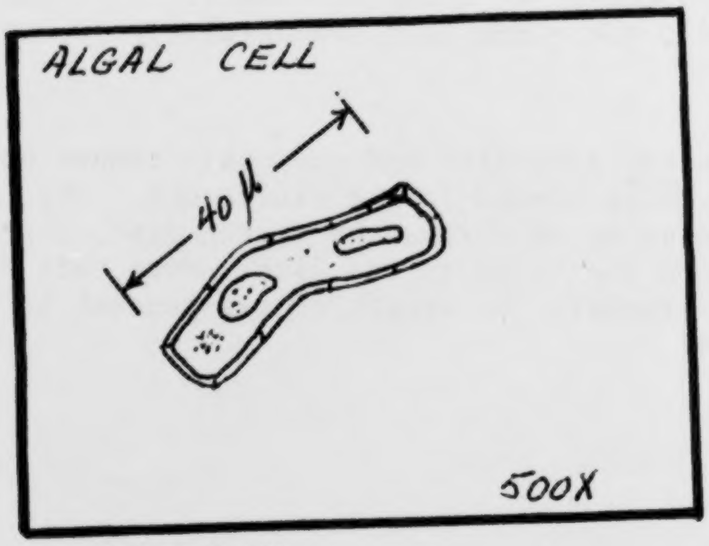
Frequently it will be desirable to prepare sketches of objects as they appear in the field of view of a microscope. When this is done certain standard procedures should be followed.

1. The drawing or sketch of the object seen in the field of view may be any size.

2. The object shown in the drawing should be identified.

3. The size of the drawing compared to the actual size of the object should be given as a "magnification" or "X" number.

$$\text{Magnification \#} = \frac{\text{dimension of the object in drawing}}{\text{measured value for the same dimension in the field of view}}$$



(LOW POWER)

$$\text{mag \#} = \frac{2.0\ \cancel{\text{cm}}}{40\ \cancel{\mu}}\ \frac{1\text{x}10^4\ \cancel{\mu}}{1\ \cancel{\text{cm}}}$$

$$= 500\text{X}$$

$$\boxed{1\text{X}10^4 \mu = 1\ \text{cm}}$$

Procedure

1. Prepare a wet mount of algal cells and view them on low power. Pick out one cell. Measure its length in μ and make a drawing of the cell on your report sheet.

2. Prepare a wet mount of a human hair. Observe the slide on high power. Measure the width of the hair in μ. Make a drawing of the hair as it appears in the field of view under high power.

Skill Development

Name ____________________

Science I___ Hour _______

Date ____________________

USING THE COMPOUND MICROSCOPE

Part C: VIEWING TECHNIQUES

1. What is the position of the letter "e" as seen through the microscope? ____________________
2. When the slide is moved toward the left the image is seen to move toward the ____________________.
3. When the slide is moved away from you the image is observed to move ____________________.
4. When the objective is changed from low to high power the position of the image seen in the field of view is ____________________.
5. While viewing an object on high power does the field of view show a larger or smaller area of the object? ____________________
6. When the objective is changed from low power to high power is the brightness of the field of view greater or less? ____________________
7. When focusing the microscope, while looking through the eye piece, the course adjustment should be turned so that the objective moves (a) away (b) toward the slide. ____________

Part D: CARE OF THE MICROSCOPE

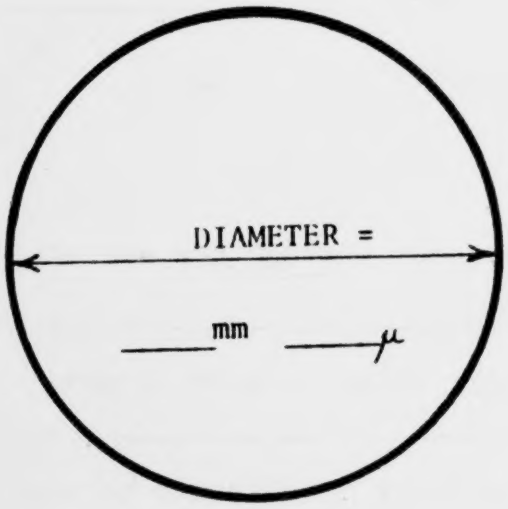
Before returning the microscope to the storage cabinet:

1. Which objective should be in place? ____________________
2. How far should the bottom of the objective lens be from the stage? _____
3. When the microscope is put away the body of the instrument should be (a) slightly tilted (b) in an upright position. ____________________
4. Cover slips and slides should be (a) thrown away (b) cleaned and returned for future use . ____________________

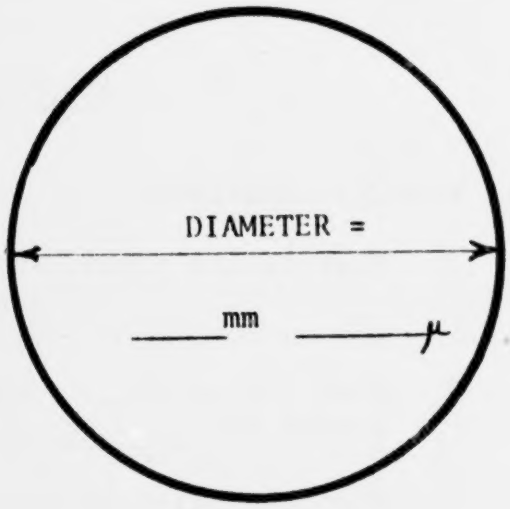
Part E: MICROSCOPIC MEASUREMENT

1. The magnification factor of the eyepiece is ____________________
2. The magnification factor of the low power objective is ______________
3. The theoretical magnification of the microscope with the low power objective is ____________________
4. The distance between micron disc teeth on low power. __________μ
5. The distance between micron disc teeth on high power. __________μ

6. Actual diameter of the field of view. LOW POWER



7. Actual diameter of the field of view. HIGH POWER



7. The actual ratio between the magnification of the low power objective and the high power objective for this microscope is

____

Part F: TECHNIQUES FOR REPORTING OBSERVATIONS IN MICROSCOPIC WORK

LOW POWER

Algal Cell

a) length of drawing _______________cm

b) length of cell as seen in field of view _______________μ

c) MAGNIFICATION OF DRAWING _______________X

HIGH POWER

Human Hair

a) width of drawing _______________cm

b) width of hair as seen in field of view _______________μ

c) MAGNIFICATION OF DRAWING _______________X

SIGNIFICANT FIGURES

Significant figures are digits which represent the number of units counted with reasonable assurance in a measurement.

The following digits are to be considered significant: (Significant figures in examples are underlined.)

1. All non-zero integers. (1-9) Exs. $\underline{3}\underline{5}\underline{4}\underline{6}$ T; $\underline{8}\underline{1}\underline{6}$ g; $.\underline{5}\underline{3}\underline{3}$ g
2. Zero when it is between 2 non-zero digits. Exs. $\underline{1}\underline{0}\underline{0}\underline{6}$ g; $\underline{5}\underline{0}.\underline{0}\underline{4}$ g
3. Zero when it is to the left of an expressed decimal point and to the right of a non-zero digit.
   Exs. $\underline{1}\underline{0}\underline{0}.$ g; $\underline{3}\underline{0}\underline{0}\underline{0}.$ T; But not in $\underline{1}00$ g nor $\underline{3}000$ T
4. Zero when it is to the right of a decimal point and to the right of a non-zero number.
   Exs. $\underline{1}.\underline{0}\underline{0}$ g; but not! $\overset{\uparrow}{0}.\underline{3}\underline{0}\underline{0}$ g; $0.00\underline{4}$ g
   $\underline{2}.\underline{0}\underline{6}\underline{0}$ g; not this one; not these

OPERATION RULES WITH SIGNIFICANT FIGURES

Addition and Subtraction: A number in a list of numbers is considered least accurate when its last significant figure is the furthest decimal place to the left.

Ex.

$$\begin{array}{rl} 3.016 & \text{g} \\ 8.1 & \text{g} \\ 55 & \text{g} \\ 49.65 & \text{g} \\ \hline 115.766 & \text{g} \end{array} \qquad \underline{1}\underline{1}\underline{6}\ \text{g}$$

The last significant figure in this number is → in the one's place. The answer should retain significant figures to the one's place.

Multiplication and Division: The number of significant figures in a product or quotient is determined by that number in multiplication or division which has the smallest number of significant figures.

Ex.

$$\begin{array}{rl} 50.200 & \text{(5 Significant Figures)} \\ 300. & \text{(3 Significant Figures)} \\ \hline \underline{1}\underline{5}\underline{0}60.000 & \text{(Answer should have 3)} \end{array}$$

$\underline{1}\underline{5}\underline{1}00$ ← no decimal point

(All future calculations should reflect these rules on significant figures. A calculated value should have no more significant figures than appear in the least accurate number.)

Science IA

Name ______________________________

Science IA Hour _______

Date ______________________________

THE METRIC SYSTEM - 2

Conversion Factors

1 inch = 2.54 cm
1 lb. = 454 g
1.06 qt. = 1.00 liter

1. Convert each of the following quantities to the required English units.

a. 20 meters = ______________________ inches = ___________ ft.
b. 1270 centimeters = ______________________ inches
c. 4.60 liters = ______________________ quarts
d. 227 grams = ______________________ pounds
e. 2.2 kilograms = ______________________ pounds

2. Convert each of the following quantities to the required metric units.

a. 1.5 inches = ______________________ centimeters = _________ meters
b. 19.685 inches = ______________________ meters
c. 2.640 quarts = ______________________ liters
d. 3.5 oz. = ______________________ dekagrams
e. 15.4 pounds = ______________________ decigrams

3. A cylindrical container is 2 inches in diameter and 5 inches long.

a. What is its volume in ml? ______________________ ml

b. How many grams of water can it hold? ________________ g

4. A box is one foot long, 54 mm wide and one inch deep. What is the volume in cc? ______________________________cc

5. A certain container holds 660 pounds of water. What is the volume in liters? ______________________l

6. A recipe calls for 50 grams of sugar. How many pounds is this? ________lb.

7. Calculate the weight of 1 ft^3 of water (assume $4^{o}C$). _______________g.

8. Calculate your height in meters. _____________________m.

9. Calculate your weight in kilograms. ______________________kg.

A. Historical Development of Systems of Measurement

1. The story of Egyptian measurement

2. Greek system of measurement

3. The system of measurement in early England

a. length -

b. area -

c. volume -

d. weight -

4. The revised system in England.

B. The Metric System

1. Development

2. Standards

	SYSTEMS	
	centimeter-gram-sec (CGS)	meter-kilogram-sec (MKS)
a. length	______________	______________
b. weight	______________	______________
c. time	______________	______________

3. Metric-English Equivalents

	FPS	CGS	MKS
a. length	1 ft	30.5 cm	0.305 m
	1 in	2.54 cm	
b. weight	1 lb	454 gm	.454 kg
c. time	1 sec	1 sec	1 sec

Problem Assignment

Name ________________
Science IA Hour ____
Date ________________

METRIC SYSTEM - 3

1. Convert 48 ounces to decigrams.

2. Convert 220 milliliters to quarts.

3. Convert 48 kilograms to tons.

4. Convert 10 miles per hour to meters per second.

5. Convert 62.4 pounds per cubic foot to grams per cubic centimeter.

6. A pipe with a diameter of 6 inches has water flowing through it at a rate of 4 miles per hour. How long will it take to fill a 100 liter container? Answer should be in seconds.

SCIENTIFIC NOTATION

There are many numbers in science that are very large or very small and would involve in their writing many zeros as place holders. To avoid that we use "scientific notation", the writing of these numbers as a numberal (A) times any power (n) of ten. $(A \times 10^n)$. One example would be the distance to the sun 93,000,000 miles written in scientific notation as 9.3×10^7 miles. Notice that there is only one digit to the left of the decimal point. This number is in "standard form."

Standard form of scientific notation is the form in which the decimal point in the numeral is written to the right of the first digit, and then the factor which is a power of ten is written. To write numbers in the standard form use the following method.

(1) Write the significant digits, a times sign (x) or (·) and a 10.

(2) Place a caret (∧) in the original number where the decimal point is to be placed (that is counting from the left) at the right of the first non-zero digit.

(3) Starting at the right of the caret in the original numberal count the places--that is, the digits and zeros passed over--in reaching the decimal point. The result of the count is the value of the exponent. If the count to the original decimal point moves to the right, the exponent is positive (+). If the count moves to the left the exponent is negative (-). Then write in the proper symbol for the exponent of 10.

Examples: $1_\wedge 360{,}000 = 1.36 \times 10^6$
count right 6 places to understood decimal point (+6)

$.00004_\wedge 38 = 4.38 \times 10^{-5}$
count five places to the left (-5)

To change a number in scientific notation to its decimal form the opposite process is performed. The exponent indicates how many places from the decimal point you move and the sign indicates the direction to move (+) to the right and (-) to the left of the decimal, adding zeros where necessary as placeholders.

Examples: $3.65 \times 10^5 = 365{,}000$
5 places to the right of the present decimal point.

$9.64 \times 10^{-4} = .000964$
4 places to the left of present decimal.

The four operations of addition, subtraction, multiplication, and division can be performed with numbers in standard form just as easily as with those in decimal form. Multiplication and division will be studied now.

To multiply numbers in standard form multiply the numerals as in arithmetic and add the exponents of 10 according to the following rules:

(1) If the signs of all exponents are alike add as in arithmetic, the answer takes the sign of the addends.

(2) If the signs are unlike find the difference as in arithmetic, the answer takes the sign of the larger number.

Examples: $3 \times 10^{5} \cdot 4 \times 10^{-8} = 12 \times 10^{-3}$ but in standard form 1.2×10^{-2}

To divide numbers in standard form divide the numerals as in arithmetic and perform the following operation on the exponents.

(1) Change the sign of the exponent on the divisor only.
(2) Continue according to the rules for adding the exponents in multiplication.

Problems

Name ____________________

Science IA Hour ______

Date ____________________

SCIENTIFIC NOTATION

I. Write each of the following in standard form.

1. 65.4
2. 34,500,000
3. 800,000
4. .0123
5. .36
6. .000763
7. 303,000
8. .00563
9. .0000003964
10. 807,431,000

II. Write each of the following in decimal form.

1. 10^{3}
2. 10^{8}
3. 10^{-3}
4. 10^{-5}
5. 3.21×10^{3}
6. 1.11×10^{-1}
7. 8.60×10^{-14}
8. 4.3×10^{-4}
9. 3.21×10^{-1}
10. 7.63×10^{-6}

III. Do the following operations. Answers should be in standard form.

1. $2.4 \times 10^{7} \cdot 6 \times 10^{-11}$
2. $3.1 \times 10^{-8} \cdot 4 \times 10^{-15}$
3. $4.3 \times 10^{10} \cdot 5 \times 10^{11}$
4. $9.8 \times 10^{-16} \cdot 4 \times 10^{9}$
5. $1.5 \times 10^{9} \cdot 8 \times 10^{-4}$
6. $\dfrac{1.8 \times 10^{-7}}{3 \times 10^{8}}$
7. $\dfrac{3 \times 10^{4}}{6 \times 10^{-8}}$
8. $\dfrac{4.2 \times 10^{-8}}{7 \times 10^{-15}}$
9. $\dfrac{6 \times 10^{25}}{4 \times 10^{25}}$
10. $\dfrac{2.4 \times 10^{5}}{9.6 \times 10^{11}}$

THE SLIDE RULE

The slide rule consists of three parts: 1) the body; 2) the slide; 3) the cursor or indicator, with its hairline. The scales on the body and slide are arranged to work together in solving problems, and each scale is named by a letter or other symbol. The hairline on the indicator is used to help read the scales and adjust the slide.

The scales which will eventually be used are:

a. C and D scales - multiply and divide

b. A and D or B and C scales - find squares and square roots

c. K and D scales - cubes and cube roots.

The scale labeled C and the scale labeled D are exactly alike. The total length of these scales has been separated into many parts by fine lines called"graduations". If these scales were long enough the total length of each would be separated into 1000 parts. First they would be separated into 10 parts. Then each of these parts would again be separated into 10 parts. Finally each of these smaller parts would be separated into 10 parts, making a total of 1000 small parts. On the C and D scales the parts are not all equal. They are longer at the left-hand end than on the right-hand end. At the left end there is enough space to print all of the fine graduations. Near the right end of a short rule there is not enough room to print all of the graduations. In using the rule, however, you soon learn to imagine that the lines are all there, and to use the hairline on the indicator to help you locate where they should be.

The marks which first separate the scale into 10 parts are called the "primary" graduations. The marks which divide each of the 10 parts into tenths are called the "secondary" graduations. Both the C and D scales have the "primary" and "secondary" graduations. Both the C and D scales have the "primary" and "secondary" graduations printed on the scale. The graduations which divide the scale into 1000 parts, or "tertiary" graduations are not all printed on the scale. The number 1 at the far left of each scale is called the "left index" and the number 1 at the far right of each scale is called the "right index".

The numbers printed on the scales tell you only the "digits" the number contains. They do not show the location of the decimal point.

The A scale is a contraction of the D scale. The A scale represents the D scale shrunk to half its former length and printed twice on the same line.

The K scale is also a contraction of the D scale. The K scale represents the D scale shrunk to one third its former length and printed three times on the same line.

The B scale is the same as the A scale.

TO MULTIPLY USING THE SLIDE RULE

1. Find the multiplicand on the D scale.
2. Move either the right or left index (1) on the C scale directly over the multiplicand. (Use the hairline to line up the numbers).
3. Move the cursor so the hairline is on the multiplier on the C scale.
4. Read the product directly below the **multiplier** on the D scale.
5. Determine the position of the decimal point by using powers of 10, scientific notation.

EXAMPLES:

15 x 3.7 = 55.5

280 x 0.34 = 95.2

.0215 x 3.79 = .0815

2.9 x 3.4 x 7.5 = 73.9

343 x 91.5 x .00532 = 167

13.5 x 709 x .567 x .97 = 5260

TO DIVIDE USING THE SLIDE RULE

1. Find the dividend on the D scale.
2. Move the cursor so that the divisor on the C scale is directly over the dividend on the D scale. (Use the hairline to line up the numbers.)
3. The quotient is on the D scale directly below the right or left index (1) of the C scale.
4. Determine the position of the decimal point using powers of 10, scientific notation.

EXAMPLES:

83/7 = 11.86

75/92 = .815

137/513 = .267

17.3/231 = .0749

8570/.0219 = 391,000

COMBINED MULTIPLICATION AND DIVISION

EXAMPLES:

$$\frac{27 \times 43}{19} = 61.1$$

$$\frac{.691 \times 34.7 \times .0561}{91,500} = .0000147 \text{ or } 1.47 \times 10^{-5}$$

$$\frac{5.17 \times 1.25 \times 9.33}{4.3 \times 6.77} = 2.07$$

Problems

Name ______________________
Science IA Hour _____
Date ______________________

SLIDE RULE MULTIPLICATION

Do the following problems on the slide rule. Use scientific notation to place the decimal point.

	Estimated Answer	Answer (Standard Form)
1. 15 x 3.7	______________	____ . ____ ____ x 10
2. 2.56 x 1.6	______________	____ . ____ ____ x 10
3. 6 x 75	______________	____ . ____ ____ x 10
4. 3.1 x 4.1	______________	____ . ____ ____ x 10
5. .161 x 9.34	______________	____ . ____ ____ x 10
6. 520 x 3.5	______________	____ . ____ ____ x 10
7. 148,000 x 204	______________	____ . ____ ____ x 10
8. .0196 x .29	______________	____ . ____ ____ x 10
9. 2.5 x 605 x 94	______________	____ . ____ ____ x 10
10. 2.55 x 3.1416 x 108	______________	____ . ____ ____ x 10
11. 981 x 0043	______________	____ . ____ ____ x 10
12. 4.3 x .715	______________	____ . ____ ____ x 10
13. 2.8 x 5.1 x 96	______________	____ . ____ ____ x 10
14. 8680 x 8.41	______________	____ . ____ ____ x 10
15. 706 x 403	______________	____ . ____ ____ x 10
16. 508 x 8064	______________	____ . ____ ____ x 10
17. 97.6 x .000505	______________	____ . ____ ____ x 10
18. $4.2 \times 10^{18} \cdot 860 \cdot 3.22 \times 10^{-8}$	______________	____ . ____ ____ x 10
19. $6.02 \times 10^{-4} \cdot 3.06 \times 10^{-19}$	______________	____ . ____ ____ x 10
20. $6.42 \times 10^{23} \cdot 1.6 \times 10^{-8} \cdot 7.18 \times 10^{9}$	______________	____ . ____ ____ x 10

Science IA
Problems

Name ________________
Date ________ Hr. ____

SLIDE RULE DIVISION

Do the following division problems on the slide rule. Use scientific notation to get the placement of the decimal point.

	Est. Ans.	Answer		Est. Ans.	Answer
1. $\frac{6.4}{2}$	________	__.__ __ x 10	11. $\frac{536,000}{320}$	________	__.__ __ x 10
2. $\frac{940}{3.5}$	________	__.__ __ x 10	12. $\frac{926}{.0647}$	________	__.__ __ x 10
3. $\frac{225}{13}$	________	__.__ __ x 10	13. $\frac{955}{852}$	________	__.__ __ x 10
4. $\frac{10.04}{1.60}$	________	__.__ __ x 10	14. $\frac{.00692}{.00085}$	________	__.__ __ x 10
5. $\frac{2.01}{52}$	________	__.__ __ x 10	15. $\frac{.00760}{.051}$	________	__.__ __ x 10
6. $\frac{4990}{307}$	________	__.__ __ x 10	16. $\frac{.0409}{161}$	________	__.__ __ x 10
7. $\frac{3500}{.063}$	________	__.__ __ x 10	17. $\frac{6.02 \times 10^{23}}{4.2 \times 10^{-9}}$	________	__.__ __ x 10
8. $\frac{195}{.955}$	________	__.__ __ x 10	18. $\frac{7.61 \times 10^{-8}}{3.16 \times 10^{-4}}$	________	__.__ __ x 10
9. $\frac{475}{17}$	________	__.__ __ x 10	19. $\frac{43.6 \times 10^{10}}{8.76 \times 10^{-4}}$	________	__.__ __ x 10
10. $\frac{842}{.00334}$	________	__.__ __ x 10	20. $\frac{1.06 \times 10^{-9}}{2.08 \times 10^{-5}}$	________	__.__ __ x 10

Science IA
Slide Rule

Name ______ ______
Date Due ______ Hr. __

COMBINED OPERATIONS

	Estimated Answer	Answer
1. $\frac{40 \times 60}{3 \times 4}$	______	___.___ ___ x 10
2. $\frac{20 \times 40}{8}$	______	___.___ ___ x 10
3. $\frac{16 \times 8}{3}$	______	___.___ ___ x 10
4. $\frac{50 \times 8}{4 \times 7}$	______	___.___ ___ x 10
5. $\frac{16 \times 41}{8 \times 4}$	______	___.___ ___ x 10
6. $\frac{18 \times 14}{22 \times 40}$	______	___.___ ___ x 10
7. $\frac{46 \times 51}{63 \times 79}$	______	___.___ ___ x 10
8. $\frac{36 \times 0.23}{1.8 \times 41}$	______	___.___ ___ x 10
9. $\frac{61 \times 3}{4 \times 8}$	______	___.___ ___ x 10
10. $\frac{23 \times 34 \times 71}{6 \times 41}$	______	___.___ ___ x 10

Science IA
Problems

Name____________________
Science______Hour__________
Date Due__________________

SLIDE RULE COMBINED OPERATIONS

Do the following problems on the **slide rule.** **Use scientific notation** to place the decimal point.

	Estimated Answer	Answer (STANDARD FORM)
1. $\frac{160 \times 75}{28.5 \times 22}$	______________	____.____ ____ x 10
2. $\frac{550 \times 82}{20 \times 22}$	______________	____.____ ____ x 10
3. $\frac{156 \times 3.36}{72.5 \times 12.8}$	______________	____.____ ____ x 10
4. $\frac{.0063 \times .0495}{.000012 \times 18}$	______________	____.____ ____ x 10
5. $\frac{360 \times 458 \times 95}{92 \times 13 \times .00012}$	______________	____.____ ____ x 10
6. $\frac{143.5 \times 2.3 \times 2}{82 \times 56}$	______________	____.____ ____ x 10
7. $\frac{236 \times 84}{14 \times 51}$	______________	____.____ ____ x 10
8. $\frac{.008 \times 3.1}{.012 \times 6.1}$	______________	____.____ ____ x 10
9. $\frac{4 \times 22 \times 17}{2.1 \times 1.09}$	______________	____.____ ____ x 10
10. $\frac{64 \times 8.1 \times 1.3}{7 \times .004 \times 5.1}$	______________	____.____ ____ x 10

Resource Materials

UNDERSTANDING THROUGH GRAPHIC REPRESENTATION

Required Reading:	"Graphs Without Graft", Current Science, Sept. 30 - Oct. 4, 1963, Vol. XLIX, No. 4 "Techniques of Graphing", Terms, Tables, and Skills for the Physical Sciences, pages 64-76

QUESTIONS FOR CONSIDERATION:

1. The points on a graph represent the data collected. Under what conditions is one justified in joining these points on the graph with a line? Under what conditions would a joining of the data points be misleading and therefore undesirable?

2. What kind of data would be best represented by a line graph? What kinds of data would be best represented by a bar graph (histogram)?

3. Discuss the advantages and limitations of a bar graph.

4. The graph in Current Science, No. 4, which shows the depth of water/light intensity relationship, is typical of a function called the "inverse proportionality". At what depth would the light intensity be zero? What special characteristics of this kind of function are illustrated by this point?

5. If the graph for the relationship between two physical quantities turns out to be a straight line, what must be true about the variable?

6. Describe the shape of the curve that would be produced for:
   a. a direct square proportionality.
   b. an inverse square proportionality.

7. Try to think of a relationship involving a common geometric form which shows an inverse variation as the square of one of the variables. Give the figure a set of values, make up a table for the variables, and construct the graph.

8. Discuss the advantages in representing numerical data graphically.

UNDERSTANDING THROUGH GRAPHIC REPRESENTATION

The purpose of any experiment, as a part of the process of science, is to provide data which the investigator may use to evaluate a hypothesis, answer a specific question, or to provide information about a particular material or process. While conducting an experiment the investigator observes what is happening and keeps a record of the data. When the experiment is completed he attempts to evaluate this information.

If an experiment is to be successful it must provide data which is accurate and informative. The data must have meaning for the investigator, and he, in turn must be able to translate and interpret this meaning for others.

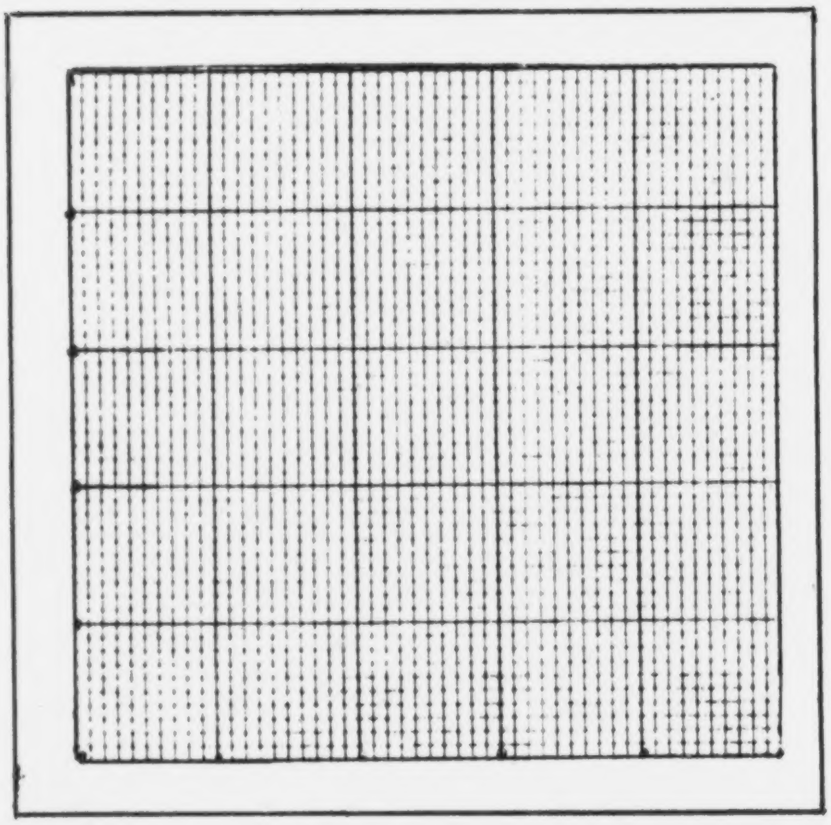
In all experiments the analysis and interpretation of the data is a most important part of the experience. It is only after making a careful and thoughtful analysis of the information provided by the experiment that one is able to draw conclusions. If the experiment is successful, the data it has provided has "something to tell" the investigator.

In some experiments the analysis and interpretation of the data is not an easy task. The story the data has to tell may be difficult to understand. In order to simplify the process as much as possible, the investigator must take care to identify and organize the data so that the relationships between one piece of information and another begin to make sense. The story that the data has to tell doesn't make sense until the words are placed in the proper order.

One form of organization which helps the investigator to interpret his data is a graphic representation. This is especially true when the data includes two or more sets of quantitative values that must be analyzed. Many times important relationships between sets of numerical data are not apparent to the investigator until the information is analyzed graphically.

When analyzing quantitative data we are usually interested in trying to determine whether the numerical values, representing measured physical quantities, have a pattern which makes it possible to describe their relationship mathematically. If a relationship such as this does exist, it is possible to develop a precise model, a mathematical model, to represent the idea we are trying to understand. The mathematical statement, once established, is not only useful in explaining the relationship between the physical quantities for which data is available, but even more important, the statement can be used to predict relationships for a whole range of values.

If physical quantities have a mathematical relationship, the graphic representation of the physical quantities will produce either a straight line or a smooth curve. Thus our initial purpose in graphing a set of data is to determine whether the relationship between the physical quantities produces either a straight line or a smooth curve. If such a relationship does exist, one can then describe it by means of a mathematical statement.



I. Types of Graphing

  A. Line Graph

  B. Bar Graph (Histogram)

II. Techniques of Graphing

  A. Parts of a Graph

    1. Horizontal axis "x"

    2. Vertical axis "y"

    3. Line or Bar

  B. Standard Form for Preparing Graphs

    1. Determination of Coordinates

      a. Independent Variable

      b. Dependent Variable

    2. Choice and Use of the Scale

    3. Labeling the Axes

4. Location of Points

5. Drawing the Curve

6. Labeling the Graph

III. Interpretation of Graphs

A. Direct Proportionality

1. Shape

2. The Constant of Proportionality

3. The Slope

B. Inverse (or Indirect) Proportionality

1. Shape

2. Effect of Graphing the Reciprocal of a Variable for an Inverse Proportionality

C. Graphs Representing Square or Square Root Proportionalities

1. Shape of Non-Linear Relationships

a. Direct Square

b. Inverse Square

2. Value of Graphing the Square or Square Root of Variables

IV. Purpose and Value of a Graphic Representation of Experimental Data

A.

B.

C.

D.

Exercise

Name ____________________

Science I Hour ______

Date ____________________

GRAPHIC INTERPRETATION OF DATA

1. How is the area bounded by a circle related to the diameter of the circle? Assume that you have eight circles varying in size from diameters of one centimeter to eight centimeters. Calculate the circumference of each circle. Complete the table shown below and represent the relationship between the diameter and area graphically.

DIAMETER	CIRCUMFERENCE

a. In this relationship, what is the dependent variable?

____

b. Calculate the slope of the line.

____

c. Write a mathematical statement to describe the relationship represented by the graph.

____

2. How is the length of a rectangle related to its width? Assume that you have a rectangle having an area of 100 cm^2. Choose ten possible values for the length and calculate the corresponding values for the width. Complete the table below and represent the relationship between the length and width of the rectangle graphically.

LENGTH	WIDTH

a. In this relationship, how would the shape of the graph change if the variables selected for the x and y axes were reversed?

b. For this relationship, what is the dependent variable?

c. How is the length of a rectangle related to its width?

d. How would the shape of the curve for a rectangle of any other area compare to this one?

e. Write a mathematical statement to describe the relationship represented by the graph.

Review

I. Awareness and the Senses

   A. By what means does man become aware of change?

   B. What is knowledge?

   C. What is Science?

      1. What is the purpose of science?

      2. What is the purpose of science education?

II. Sensory Experience and Physical Quantities

   A. How reliable are the senses?

   B. What is a physical quantity?

   C. Discuss the difference between a defined and undefined physical quantity.

   D. What is meant by FPS, CGS, MKS?

   E. Identify three undefined physical quantities.

III. Use of the Compound Microscope as a Measuring Instrument

   A. Calculation of the "power" of a compound microscope

B. Determination of magnification of object

C. Calculation of field of view

IV. Metric System

A. Structure of metric system

1. standard units

2. prefixes

B. Metric-English equivalents

1. length

2. weight

3. volume

C. "Rate Pair" method of conversion

D. Problems in conversion

1. convert 3.5 hectometers to decimeters -

2. convert 3516 milliliters to dekaliters-

3. convert 1,560,000 milliliters to cubic feet -

4. convert 1.1 kilogram to ounces -

5. convert 1000 inches to meters -

V. Significant Figures

A. Definition

B. Retaining significant figures in a

1. Sum

2. Difference

3. Product

4. Quotient

C. Examples

1. How many significant figures in the following?

(a) 1.0032 g
(b) 1.005 tons
(c) 1.030 g
(d) .10 ml
(e) 100 lb
(f) 150. ml

2. Add. 430 lb., 365 lb., and 605.2 lb.

3. Multiply 4.2 cm by 8 cm.

VI. Scientific Notation

A. Expression of numbers in "standard form."

B. Multiplication of numbers in standard form.

C. Division of numbers in standard form.

D. Examples:

1. Express the following in standard form:

a. 462000

b. 0.000000652

c. 1462.0002

2. Convert the following to decimal form.

a. 1×10^6

b. 10^{-3}

c. 3.8×10^{-1}

3. Multiply or divide as indicated. Answer should be in standard form.

   a. $3.6 \times 10^3 \cdot 2 \times 10^6$

   b. $4 \times 10^6 \cdot 3 \times 10^{-8}$

   c. $8 \times 10^{-7} \cdot 2 \times 10^{16}$

   d. $\frac{5 \times 10^{16}}{1 \times 10^{12}}$

   e. $\frac{6 \times 10^{-16}}{2 \times 10^{-7}}$

   f. $\frac{3 \times 10^{-11}}{6 \times 10^{10}}$

VII. *Slide Rule*

A. Multiplication

1. 5.1×156

2. $4.32 \times .00165 \times 873$

B. Division

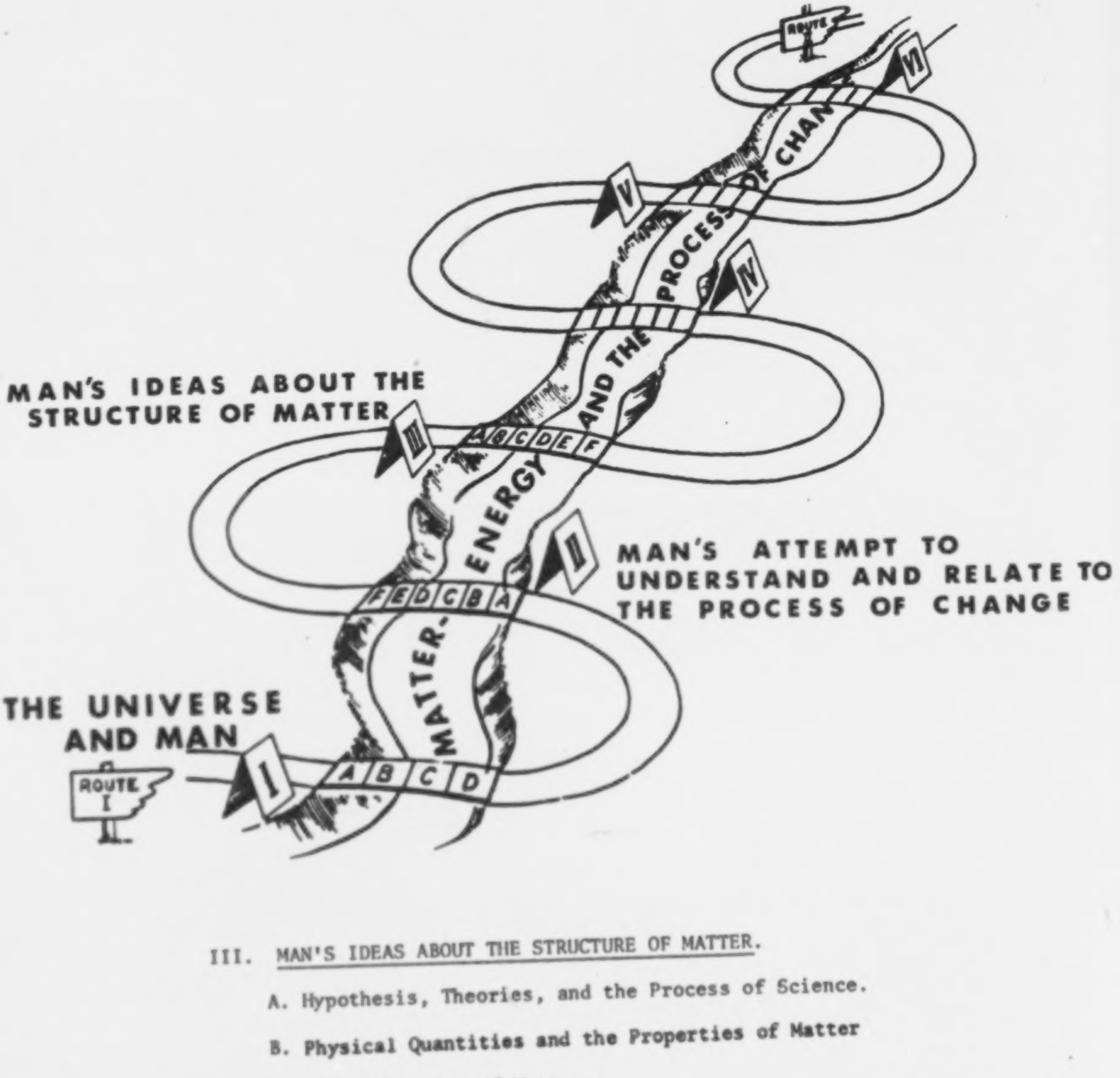
1. $\frac{508}{365}$

2. $\frac{5.1 \times 10^{-2}}{4.3 \times 105 \times 87}$

C. Combined Operations:

1. $\frac{31 \times 86 \times .00318}{56 \times 107 \times 720}$

2. $\frac{306 \times 73 \times 906}{5.32 \times 10^{-8} \times 6070}$


MAN'S IDEAS ABOUT THE STRUCTURE OF MATTER
MAN'S ATTEMPT TO UNDERSTAND AND RELATE TO THE PROCESS OF CHANGE
THE UNIVERSE AND MAN
ROUTE I
ROUTE
I
II
III
IV
V
VI
A B C D
F E D C B A
A B C D E F
MATTER-ENERGY AND THE PROCESS OF CHAN

III. MAN'S IDEAS ABOUT THE STRUCTURE OF MATTER.

A. Hypothesis, Theories, and the Process of Science.

B. Physical Quantities and the Properties of Matter

C. Classification of Matter.

D. Basic Structure of Matter: Atoms, Molecules, and Cells.

E. Particle Motion, the Kinetic State of Matter.

HYPOTHESIS, THEORIES AND THE PROCESS OF SCIENCE

"Where do scientific problems come from?" They arrive from a basic human trait: curiosity. It serves as a great driving force in science. Alfred North Whitehead, a great English philosopher and mathematician, has said that science is "almost wholly the outgrowth of pleasurable intellectual curiosity."

Scientists have strong curiosities and so they are problem seekers. It is difficult to find the right answers, but many scientists believe that it is more difficult to ask the right questions. You know people who have problems but when it comes to understanding and stating their problems clearly they often have difficulty. So does the scientist. Albert Einstein said:

> "The formulation of a problem is often more essential than its solution, which may be merely a matter of mathematical or experimental skill. To raise new questions, new possibilities, to regard old problems from a new angle, require creative imagination and marks real advance in science."

To illustrate the activity of science, let us picture a scientist as somewhat similar to a detective. A scientist, like a detective, is continually involved in problem solving. His activity is directed toward one goal, the solution of a problem.

Einstein, who ranks as one of the greatest scientists of all time, had this to say about the detective work of science:

> "In nearly every detective novel since the admirable stories of Conan Doyle there comes a time where the investigator has collected all the facts he needs for at least some phase of his problem. These facts often seem quite strange, incoherent, and wholly unrelated. The great detective, however, realizes that no further investigation is needed at the moment, and that only pure thinking will lead to a correlation of the facts collected. So he plays his violin, or lounges in his armchair enjoying a pipe, when suddenly, by Jove, he has it! Not only does he have an explanation for the clues at hand, but he knows that certain other events must have happened. Since he now knows exactly where to look for it, he may go out, if he likes, to collect further confirmation for his theory.
>
> The scientist reading the book of nature, if we may be allowed to repeat the trite phrase, must find the solution for himself, for he cannot, as impatient readers of other stories often do, turn to the end of the book. In our case the reader is also the investigator, seeking to explain, at least in part, the relation of events to their rich context. To obtain even a partial solution the scientist must collect the unordered facts available and make them coherent and understandable by creative thought."

In the preceding quotation, Einstein points out that before solving a problem, the scientist must investigate the situation and collect the "facts of the case." If a process or object can be perceived directly by the human senses, a statement about it which has been verified by these senses is called a fact. (A fact may be defined as any observation that can be confirmed by many people.)

A natural law is a generalization based upon a large body of facts related to one phenomenon or process. It may take the form of a concise statement, or it may be a mathematical equation. In either case, it summarizes all previous observations and predicts that, under the same circumstances, the same observations will be made in the future. For example, the law of definite composition is the simple statement that any two samples of the same pure substance always contain the same elements in the same proportion by weight. This statement is consistent with all past experience about the composition of substances, and predicts that the same sort of behavior will be found in all future investigations. However, since scientists are frequently redetermining the composition of known substances and are preparing new substances, some of which may be radically different from those known today, it is not impossible that some day something will turn up that is not consistent with this law. If this happens, the law will have to be modified, or restated, or perhaps even abandoned. Thus, the very quality of prediction which makes a law useful to the scientist also makes it vulnerable, for a single inconsistent observation may necessitate revision.

Laws are formulated in the belief that there is a fundamental orderliness to nature so that, under the same set of circumstances, the same results will be observed again and again. Even when observation is inconsistent with an existing law, the scientist is not likely to lose his faith in the "lawfulness" of nature. He will search for a new, more general law that is consistent also with the "inconsistent" observation. For example, there was a time when the law of conservation of mass was thought to apply to all the changes that matter undergoes. Then it was found that this law "fails" when applied to nuclear reactions. As a result, a more general law of conservation of mass-energy has replaced it; the new law applies to both chemical and nuclear reactions. And the law of conservation of mass has been restated so that it applies only to chemical reactions, where it is still valid.

As has been pointed out, scientists are not satisfied only to observe facts and formulate laws, but they try also to explain the facts and the laws. Because they are unable to perceive the innermost workings of matter directly, they invent possible explanations to account for them.

The creative part of science comes when the scientist makes a tentative solution to a problem. This solution, called a hypothesis must not only account for all the known facts, but should also predict the effects of certain other events. Explanation and prediction are the two main functions of a hypothesis.

We cannot say much about how scientists form their hypotheses, only that it can be described as an art within science. A great many scientists have stated that their hypotheses were "lucky guesses" or "inspired hunches". They could not say more than this, because they simply could not describe the steps which led them to their hypotheses. Even though the scientists themselves called their hypotheses guesses or hunches, the knowledge they possess and the work they have done helped them to make the creative leap of formulating their hypotheses.

A hypothesis, then, consists of a group of interconnected statements, or assumptions, which one assumes to be a possible solution to the problem. The hypothesis may contain one statement or it may be a complex network of statements.

Some scientists use the two terms *hypothesis* and *theory* as though they mean the same thing. However, many scientists prefer to use the term hypothesis to describe the initial attempts to solve a problem. If the hypothesis will stand repeated testing and is of general significance, it may be called a theory. Hypotheses are tested through experimentation.

This process which involves the identification of a problem, the formation of hypothesis relative to its solution, the design of procedures by which the hypotheses may be tested, and eventually the formation of theories based on the existing facts, is one of the processes by which the scientist is able to learn something new about the environment in which he lives.

HYPOTHESIS, THEORIES, AND THE PROCESS OF SCIENCE

Our major purpose in the Science I program is to become better informed about the physical universe in which we live and in so doing to develop a number of basic ideas and attitudes about the environment in which we live and share responsibilities.

Last fall be began our study with an overview of the universe as a macrocosm, of fantastic dimensions, perhaps without boundries, in space or time, within the limits of man's ability to comprehend. We have also considered the universe in microcosm and learned to expect the same orderliness of nature in this world of space and time, where dimensions become so very small as to pass again beyond the limits of man's ability to comprehend.

Throughout these studies we have been reminded again and again that man and his world are not the center of the universe.

Through the process of science man attempts to understand and describe the universe in terms of experiences within the range of his own dimension in space and time. Careful observations within our environment have shown that all matter, living as well as non-living, experiences changes as time passes. This "change as a function of time", we call evolution.

In our attempts to understand and relate to the changing universe we have learned that man becomes aware of the evolutionary process by means of his senses. We know that each of us comes into the world without knowledge or understanding but that each of us has a capacity to learn! Knowledge about ourselves and our environment comes about as a result of our conscious sensory experiences. The acquisition of knowledge through the process of science is very much dependent upon our willingness and ability to become careful detectors of change. However, our ability to acquire knowledge is not limited to our own personal experiences. Through communication, the written and spoken word, we have the opportunity to share and benefit from the experiences of others. Your success, as a student, is very much dependent upon your ability to use both of these techniques effectively.

In order to evaluate and describe our experience we have found that systems for quantative measurement are absolutely essential! We have long been familiar with one such system, the English System. We are at the present time becoming more familiar and proficient in the use of another (the Metric System), which has many advantages. We have talked about the significance of the numbers we use to describe the dimensions of time and space and force. We have talked about ways of expressing very large and very small numbers in a convenient "shorthand" method by the use of exponents (scientific notation). We have been introduced to the slide rule which may, if you choose to practice and continue to use it, become a very helpful tool in numerical calculations. We have now reached the point in our study of evolutionary processes in the physical universe where we are prepared to look much more closely at some of man's ideas about the Organizational Structure of Matter in the Changing Universe.

During the next few weeks we will be making extensive use of our laboratories and the experimental method of acquiring knowledge related to some very basic properties of matter and to the whole broad concept of the structure of matter. In order to make this type of learning experience as profitable as possible, we need to take the time necessary to identify and discuss some of the terms, techniques and attitudes that are an intregal part of this experimental process of learning.

Science IA
Resource Material

HYPOTHESIS, THEORIES AND THE PROCESS OF SCIENCE

Required Reading: Biological Science (BSCS Blue Version), pages 8-10, 54-57, 65-66, 75-78

Recommended Reading: Science of Biology, Weisz, 574 W43, pages 5-10

Art of Scientific Investigation, Beveridge, 500 Be, pages 56-71

QUESTIONS FOR CONSIDERATION:

1. Less than fifty years ago, physicists considered it proved that, because of the nature of light, no microscope could ever be built that would magnify more than the best lenses on our compound microscopes. Then came the electron microscope with its magnification of 50,000 times and more. The electron microscope uses, not light, but electrons. Physicists at once accepted the new facts and changed their previous ideas to conform with them. If all scientists had stuck to the old idea about microscopes, would the electron microscope have been discovered? Can you think of any current example in which sticking to an old belief may be blocking a search for new discoveries?

2. What does a scientist do when his original hypothesis is not suported by his experiments?

3. Various hypotheses have been formulated concerning possible origins of the solar system. Some of these hypotheses have been abandoned as untenable, others modified based on new information. What was the importance of the initial hypotheses?

4. Would it be possible to apply scientific principles to determine which one of two paintings is more beautiful?

5. Using the approach of the scientist, can you think of any way to prove that something (for example, an appearance of ghosts) can not happen?

HYPOTHESIS, THEORIES, AND THE PROCESS OF SCIENCE

I. Hypothesis

A. What is a hypothesis?

B. The value of a hypothesis:

1. Explains the facts

2. Leads to the predicting of new information

C. Testing of hypothesis through experimentation

II. Scientific Theory

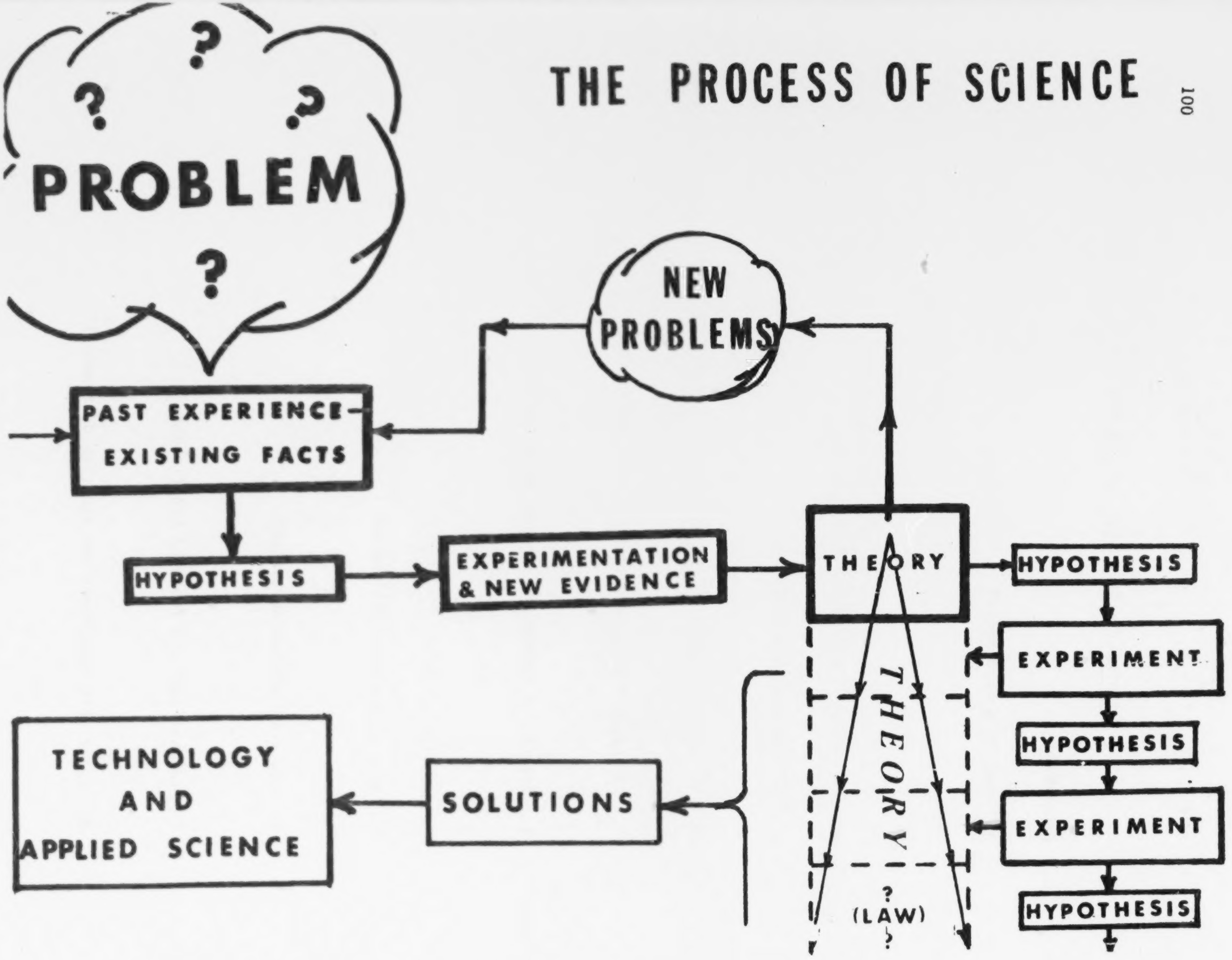
A. What is a scientific theory?

B. How are theories developed?

C. In what ways are theories beneficial?

D. Under what conditions are theories detrimental?

THE PROCESS OF SCIENCE


PROBLEM
?
NEW PROBLEMS
PAST EXPERIENCE-EXISTING FACTS
HYPOTHESIS
EXPERIMENTATION & NEW EVIDENCE
THEORY
HYPOTHESIS
EXPERIMENT
HYPOTHESIS
EXPERIMENT
HYPOTHESIS
THEORY
? (LAW) ?
SOLUTIONS
TECHNOLOGY AND APPLIED SCIENCE

III. Scientific Law

A. What is a scientific law?

B. What distinguishes theory from law?

IV. Processes in Science

Name ______________________

Science I___ Hour ________

Date ______________________

FORMATION AND USE OF HYPOTHESIS IN PROBLEM SOLVING

The following picture problem represents a pattern for a mosaic. Attempts to discover this pattern will provide an opportunity for you to test your ability to form and then use a hypothesis in problem solving.

In this particular example the problem is not related to any scientific principle and previous knowledge about mosaics is not required in order to solve the problem. The solution depends on a careful examination of the placement of the 2x2 shaded squares in each of the sample segments shown below.

A very definite set of rules has been followed in the placement of the 2x2 shaded squares. Your problem is to discover this set of rules.

PROBLEM: What are the rules which govern the placement of the 2x2 shaded squares in the mosaic pattern shown below?

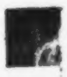
SUGGESTED PROCEDURE:

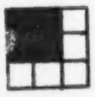
a. Examine the mosaic sections very carefully that are shown below. Look for similarities and differences between the patterns.

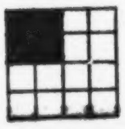
b. Form an opinion (a working hypothesis) to account for the way in which the shaded squares are arranged.

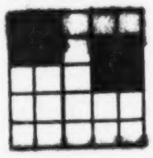
c. Test your hypothesis to see if it correctly describes the placement of the shaded squares in all of the segments shown. Any hypothesis which is true for all segments may be regarded as a rule for establishing the pattern of the mosaic.

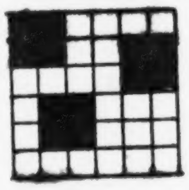
d. Establish as many rules (proved hypothesis) as you think are necessary in order to duplicate this pattern.

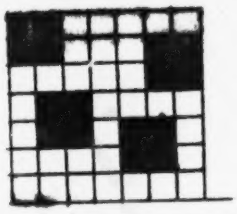

2x2

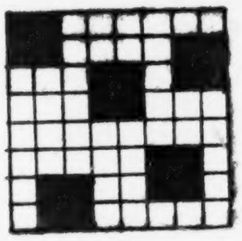

3x3

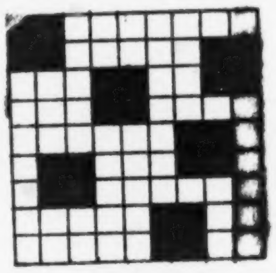

4x4


5x5


6x6


7x7


8x8


9x9

PROVED HYPOTHESIS (The Rules)

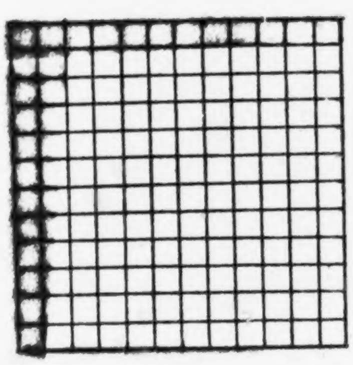
1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

?. ______________________________


12x12

Demonstrate that you have solved the problem of how the shaded squares are arranged in this mosaic pattern by using your set of Proved Hypotheses to fill in the pattern for the 12 x 12 square shown at the right.

EXPERIMENTATION IN THE "PROCESS OF SCIENCE"

The words "Experiment" and "Science" are closely allied, one suggests the other. Actually these two words could be used as synonyms in so far as both describe a process of learning. Of the two, Science is a broader term. Experimentation is a method by which one may develop knowledge.

The purpose of experimentation, as a part of the process of science, is to find answers to questions yet unanswered or solutions to problems still unresolved. It is a process which enables one to extend the boundaries of his knowledge from the known into the realm of the unknown.

The process begins with a careful analysis of the particular question or problem of concern. The investigator must think about the problem in terms of all knowledge that he can recall and relate to it. In light of that which he knows about the problem the investigator must then formulate an idea or opinion which seems to be a reasonable assumption about something which is not yet known. This idea or assumption is called a "hypothesis."

After a hypothesis has been established it becomes necessary to find some way of testing it. The process of gathering information that may be used as evidence to evaluate or judge the hypothesis is what we can "experimenting."

The search for knowledge by the process of experimenting is very much like the work of a detective. In fact, a good detective uses many experimental techniques first developed for investigating problems in science. The science experimenter is an investigator. He is a detective. He searches for evidence which may be used to clarify a problem which is not understood.

Sometimes it is very difficult to design experiments which provide the kind of information that is needed to test or evaluate a hypothesis. Consider, for example, a current hypothesis about the structure of the universe which says that space is curved like a sphere. The design of experiments that will provide reliable information useful in evaluating this idea is itself a problem, a problem so difficult and complex that no satisfactory answer has, as yet, been found.

The experimental procedures used to gather information useful in the evaluation of hypothesis vary considerably from one problem to another but all experiments have one thing in common. In all experiments the information, called "data," provided by the experimental procedures must be accurate and informative. If this is not true the experiment has little value.

Oftentimes young people become so anxious to "do the experiment" that they fail to take the time necessary to think about the problem involved and to form an initial hypothesis relative to its solution. The excitement and fun of working with new materials and equipment takes over. The student does things with little thought about why he is doing what he is doing or how this activity is related to the purpose for doing it in the first place. The result of this kind of experience is that, even though the student does gather information (data), he does not know what to do with it. The data gathered fails to be informative unless the student understands how it is to be used in evaluating an idea or to increase his knowledge about a particular substance or process.

It seems as though many beginning experimenters have the notion that somehow knowledge leaps automatically and spectacularly forward as one tinkers about in a laboratory. This, certainly, is not what happens. It is true, even today, that there is a great deal of discovery by accident but these "accidental discoveries" would go unnoticed by a person who didn't have any idea of what he was doing or the purpose for doing it.

In conclusion, one cannot over-emphasize the importance of the process of science that must precede experimentation. These are:

1. Understand the problem or question at hand so that a reason for a particular experimental procedure is clearly evident.

2. Understand, before entering into any experimental procedure, what kind of information you are looking for and how this information is to be used to evaluate an idea or to increase one's knowledge about a particular substance or process.

Experimenting, as a learning process is fun and exciting but it is meaningless and a waste of time unless the experimenter recognizes the role of experimentation in the process of science.

LABORATORY EXPERIENCES IN THE PROCESS OF SCIENCE

Laboratory experiences in the process of science are of two rather different types. One of these we shall call the "Laboratory Problem" type. This type of experience is concerned with the solution to a specific problem or the answer to a specific question. The second type of laboratory experience we shall call a "Laboratory Investigation." It differs from the problem in that it is more of an exploratory type of experience. Our purpose for conducting "Laboratory Investigations" will be to "provide the opportunity to learn" by personal experience.

Both of these types of laboratory experiences are experimental processes. We have chosen to use these terms, "Laboratory Problem" and "Laboratory Investigation" in our science program only because we hope that the use of the terms will be helpful in developing the proper attitude toward these two types of learning experiences.

THE LABORATORY PROBLEM

Before an experimenter can become actively engaged in the solution of a "Laboratory Problem" it is necessary to interpret the problem. The experimenter must develop a clear understanding of what the problem is about! He may think about the problem in terms of what he knows and determine what additional information is needed in order to solve the problem, or he may use the knowledge that he has about the problem to form a hypothesis which may then be evaluated on the basis of information provided through experimentation. In either approach the laboratory procedures are selected after the problem has been analyzed. Everything that is done is then geared to the investigator's interpretation of the problem. Each experimental procedure is designed to provide a very particular bit of information which the experimenter believes will bring him closer to a solution to the problem. After the experimental data has been collected the investigator evaluates the information and on the basis of this interpretation decides whether a satisfactory solution is then possible or whether he needs to experiment some more.

In preparing written reports for the type of laboratory work we will use a standard "Laboratory Problem Report" form shown here.

USE OF THE LABORATORY PROBLEM REPORT FORMS

The form outlined below should be used in preparing all written reports for Laboratory Problem experiments.

TITLE

PROBLEM:

State the problem to be solved exactly as it is given.

ANALYSIS OF THE PROBLEM:

(a) In this space restate the problem in your own words. This statement must give your interpretation of the problem.

(b) Following this statement you must tell what information you intend to gather in the course of the experiment, the information which you think you must have in order to solve the problem or answer the the question presented. (Avoid the use of personal pronouns.)

In the event that the problem suggests an idea or hypothesis which you would like to test, state your hypothesis and tell what information you intend to gather in order to evaluate it.

This portion of the experimental process must be completed before starting any procedures. If you have difficulty with this interpretation discuss the problem with your teachers.

EXPERIMENTAL DATA:

This portion of the report should show, in a neat and meaningful form, all measurements or other information which represent the data you set out to collect in the experiment. Do not tell how the data was collected or how it is to be used in the evaluation. Simply present the data in a clear and meaningful form. Usually a table of some sort is most appropriate.

ANALYSIS OF DATA:

This portion of the report must show how the experimental data was used to arrive at a solution to the problem or question presented, or how the data was used to evaluate a hypothesis.

The interpretation of data should be done mathematically or graphically whenever possible. A word description should not be used unless no other interpretation is possible.

CONCLUSION BASED ON THE ANALYSIS OF THE DATA:

This portion of the report should give a simple and direct answer to the PROBLEM presented. Any discussion necessary for clarification of the conclusion should be included in the Analysis of the Data.

Supplement: If any discussion relative to possible sources of error in the experiment or the analysis of data is desired it should be included as a supplement to the conclusion.

ANSWERS TO SUMMARY QUESTIONS:

If there are summary questions at the end of the experiment, these questions should be answered here. Do not copy the question over, but do number them correctly.

All reports should be done neatly! Ink or ball point pens should be used. All line drawings and tables should be made with a straight edge. Always avoid the use of personal pronouns in the report. Words like "we" or "I" do not contribute anything to the report and it is considered very poor form to include them.

Any graphs which are used in the analysis of the data should be constructed on graph paper provided and included as a part of the report.

THE LABORATORY INVESTIGATION

In the "Laboratory Investigation" type of experience no well defined problem is identified. In this type of laboratory work we are concerned with developing some means of investigating a broad range of properties with reference to a particular organism or substance, or at other times, to investigate a process by which a particular organism or substance experiences change. The purpose of this type of experimentation is to provide information which may help the investigator to understand broad concepts as they relate to the structure of matter and the process of change.

USE OF THE LABORATORY INVESTIGATION REPORT FORM

The form outlined below should be used in preparing written reports for laboratory experiments.

TITLE

GENERAL PURPOSE:

In this space the overall purpose of the entire investigation should be clearly stated.

SPECIFIC INVESTIGATIONS:

This portion of the report is divided into three sections each of which applies to a segment or particular part of the overall experiment. The type of discussion described here should be repeated for each separate part of the experiment.

Purpose of Specific Investigation:

In this space state the purpose for the investigation. This statement will be completed before starting the activity!

Observations:

In this space describe what you have observed. Omit trivial details and come directly to the point. Avoid the use of all personal pronouns! To say that I saw, or I observed is trivial and tells nothing about the observation itself.

Conclusion:

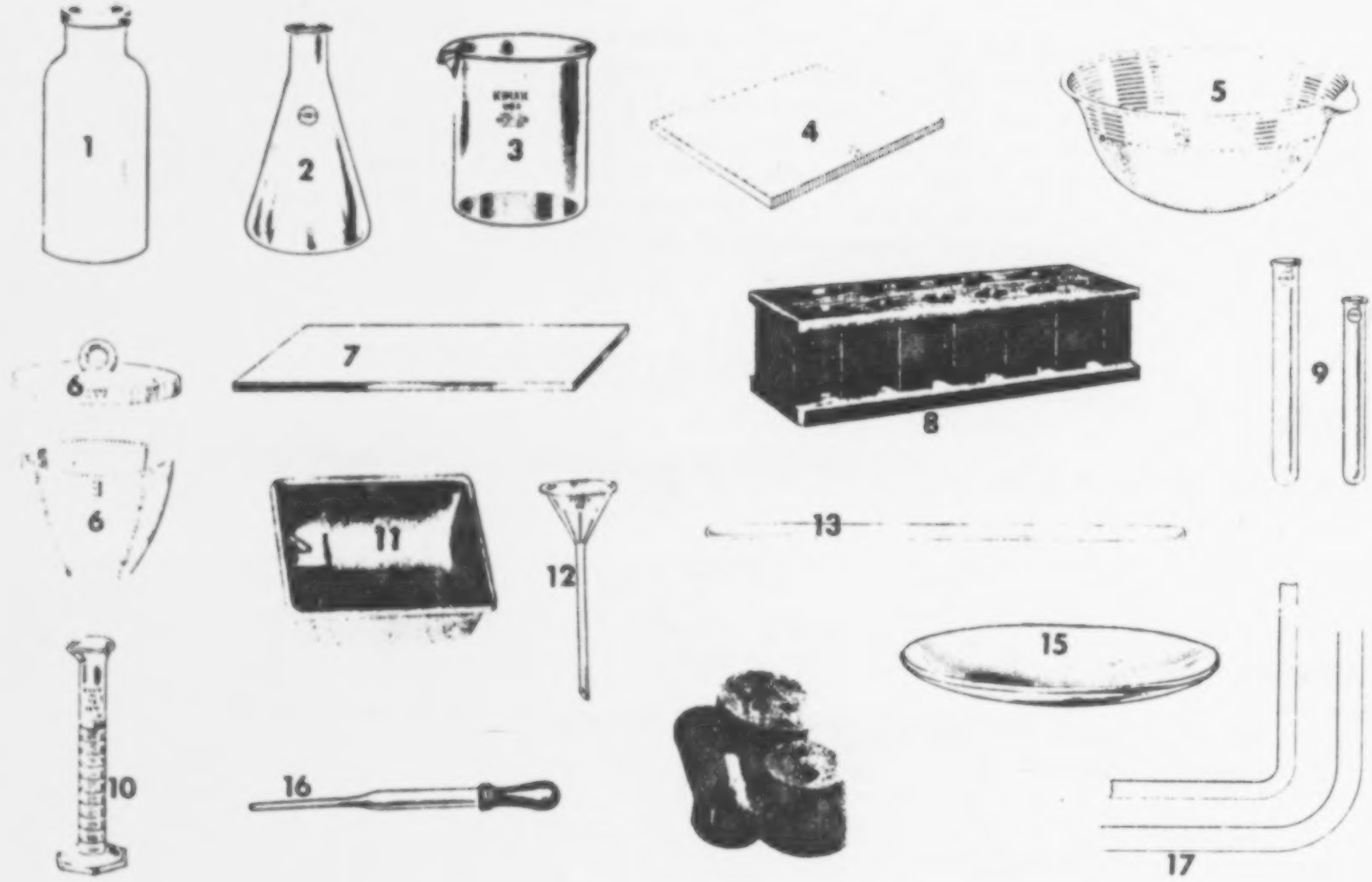
The conclusion should be a very brief statement which tells what you have learned from the investigation just completed.

SUMMARY STATEMENTS RELATING TO GENERAL PURPOSE;

After the experiment has been completed, the observations from each part should be related to the overall purpose of the investigation. The knowledge gained as a result of the investigation should be summarized as completely but efficiently as possible. Again, avoid trivial discussion. Try to use short concise statements to express your ideas.

109

1st DRAWER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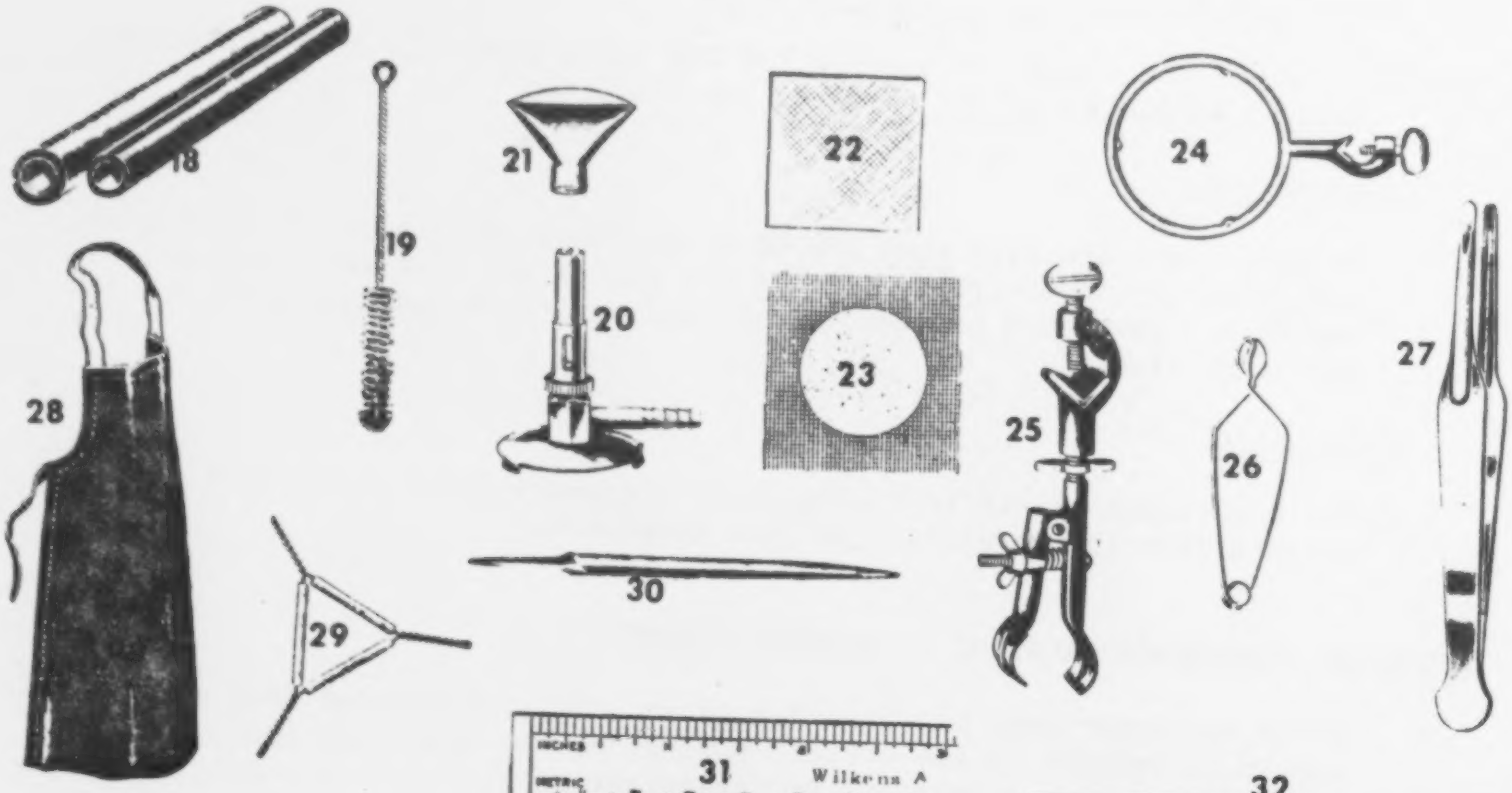
2nd DRAWER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INCHES
METRIC
31
Wilkens A
32

LABORATORY TECHNIQUES

- A. Facilities
    - 1. Desks
    - 2. Gas
    - 3. Electricity
    - 4. Water
    - 5. Ventilation
    - 6. Fire Prevention
        - a. Extinguishers
        - b. Fire Drill
    - 7. First Aid
        - a. Burns
        - b. Cuts
        - c. Chemical Injuries
- B. Chemical Supplies
    - 1. Use of Reagent Tray
    - 2. Acid-Base Tray
    - 3. Special Reagents
- C. Laboratory Rules
    - 1. Aprons

2. Waste Disposal
    a. Liquids
    b. Burnable - paper, matches, splints
    c. Non-burnable - glass, chemicals
3. Cleanup
    a. Sinks
    b. Equipment
    c. Desk tops
4. Purpose of the Laboratory

D. Lighting a Bunsen Burner

THE BUNSEN BURNER

PROCEDURE:

Part I

1. Make a study of the Bunsen burner by taking the burner apart (4 parts) and examining all the parts carefully. Note where the gas enters the burner, how the flow of gas is controlled and where the air enters the burner. On the report sheet write the names of the numbered parts of the burner and give the function of each part. Use the demonstration sketch as a guide.

2. Connect the burner to the gas line, partially close the air holes and light the burner. A properly adjusted burner burns with a quiet, blue (non-luminous) flame showing two distinct cones.

   The size of the air holes controls the type of flame produced by the burner. When the holes are completely open (too much air), a "strike-back" or roar is produced. See if your burner will show this effect.

   Closing the air holes will reduce the amount of air and should produce a yellow, luminous flame. The yellow color of the flame is caused by carbon particles (unburned fuel) heated to incandescence.

   Close the air holes on your burner. You will also need to wrap a folded damp paper towel tightly around the collar to effectively exclude air on our laboratory burners. Hold an evaporating dish in the tip of the luminous flame.

3. Readjust the burner to give the quiet non-luminous flame with two cones. Find the position of the hottest part of the flame by holding a platinum wire horizontally in the flame and moving it up and down, noting where the wire glows most brightly.

Part II

In this part of the investigation we shall measure the temperature of the Bunsen flame at various positions in order to determine what part of the flame is hottest and which part is the coolest.

The temperatures will be measured with a set of seven "thermo-melt" markers which range in temperature from 1600°F down to 400°F in equal steps of 200°F.

Laboratory Skill Development
Report Sheet

Name ______________________________

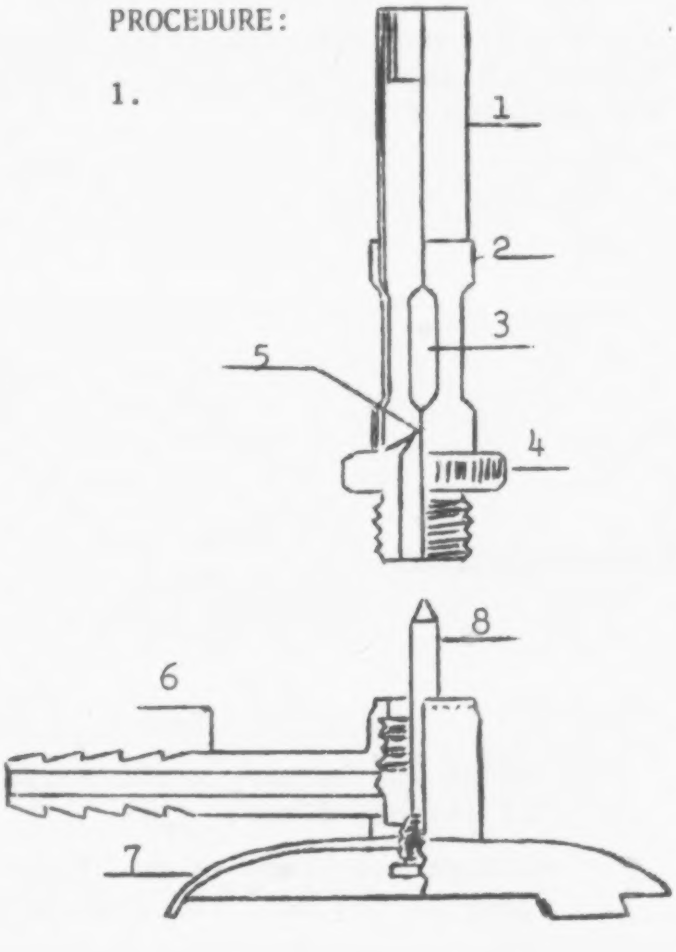
Science I___ Hour ___

Date ______________________

THE BUNSEN BURNER

PROCEDURE:

1.



	Name		Function
1.	____________	1.	____________
2.	____________	2.	____________
3.	____________	3.	____________
4.	____________	4.	____________
5.	____________	5.	____________
6.	____________	6.	____________
7.	____________	7.	____________
8.	____________	8.	____________
9.	____________	9.	____________
10.	____________	10.	____________

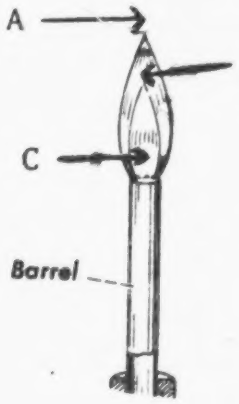
2. a. What observation did you make as the evaporating dish was held in the luminous flame?

b. The fuel used in our burners is natural gas or methane, a compound of carbon and hydrogen which has the formula CH_4. In burning or oxidation of any fuel, the greatest efficiency, the highest temperature and cleanest flames are produced when oxygen or air is well mixed with the fuel for the correct proportions to change all elements in the fuel into their oxides. In light of these facts why does closing of the air holes produce a yellow flame?

c. Why is a candle flame yellow?

d. Would you expect a candle flame to be very hot?

3. Place the correct letter in front of the descriptions of the non-luminous flame from a properly adjusted burner.



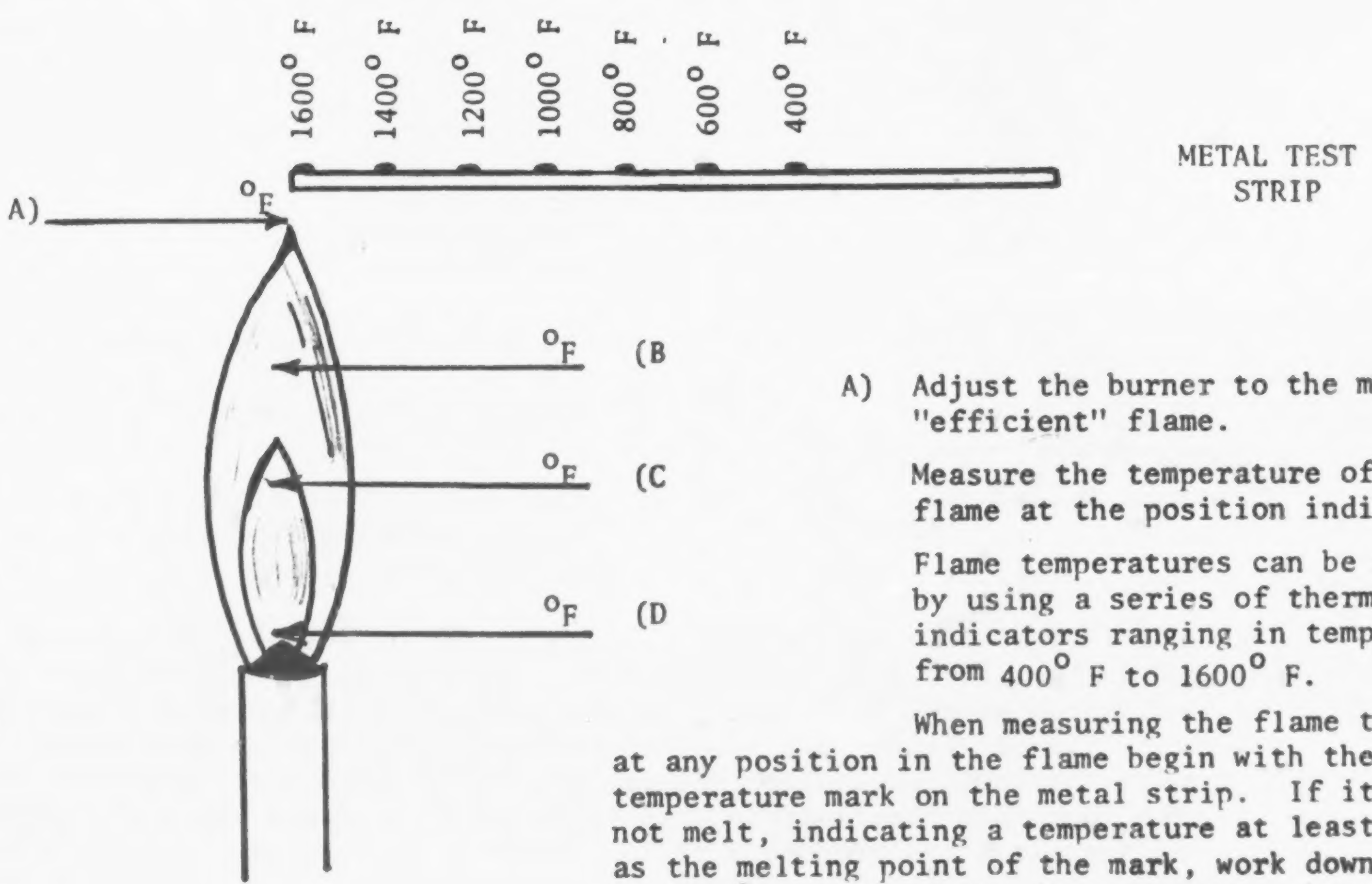
_____ hottest part of the flame

_____ dark cone - not a flame but a mixture of unburned gas and air

_____ purplish or deep blue cone where combustion is complete - the oxidizing flame

_____ light blue cone with insufficient oxygen mixed with gas giving incomplete burning - the reducing flame

Part II **Burner Efficiency**



A) Adjust the burner to the most "efficient" flame.

Measure the temperature of the flame at the position indicated.

Flame temperatures can be measured by using a series of thermomelt indicators ranging in temperature from 400° F to 1600° F.

When measuring the flame temperature at any position in the flame begin with the highest temperature mark on the metal strip. If it does not melt, indicating a temperature at least as high as the melting point of the mark, work down toward the 400° F range until the temperature has been determined.

B) Adjust the burner to give a yellow-orange flame. Measure the temperature of the flame at position B. ____________________ °F

PROPERTIES OF MATTER AND PHYSICAL QUANTITIES

I. Properties of Matter

A. General - properties of matter which indicate how all matter is alike.

B. Special - properties of matter which indicate how matter is different.

1. Physical

2. Chemical

II. Physical Quanties

A. Special Properties as Physical Quantities

1. Length

2. Force

3. Weight

4. Time

B. Word Descriptions

1. Defined

a. Density

b. Coefficient of Expansion

2. Undefined

Science I
Laboratory Investigation

GENERAL & SPECIAL PROPERTIES OF MATTER

INTRODUCTION:

The public impression of scientific experimentation is that these activities always produce spectacular results which lead to great advances in knowledge. Contrary to the common image of science most of the really great advances occur as a result of pursuing the unexpected, unanticipated observations of seemingly insignificant side effects associated with experiments which were being performed for some other purpose. The point we wish to make here is that in attempting to learn through direct experimentation one must pay close attention to detail and maintain an open mind capable of expecting the unexpected, and recognizing the significance of the seemingly insignificant.

In performing the following experiments you will find that in one sense the results are not spectacular. However, there are many subtle observations to be made which will lead you to discover more than just the obvious properties.

KEEP YOUR SENSES ALERT!

PURPOSE:

To distinguish between the general and special properties of matter. Materials to be tested are string and wire.

PROCEDURES:

1. Identify those properties of the test materials which can be detected directly by the senses.

2. Weigh the string and the wire.

3. Place the wire in the hole of the metal strip. Then, without removing the wire, thread the string through the hole.

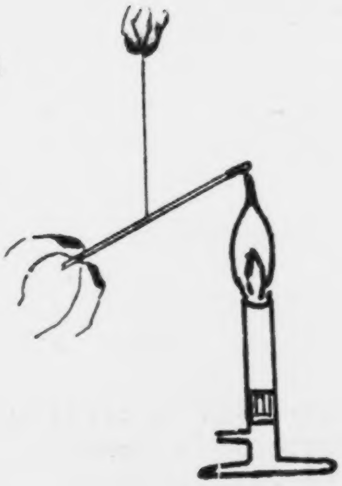
4. Suspend a length of the wire from a rigid support. Add enough weights to break the wire. Repeat this procedure with the string.

5. Determine the effect that a magnet has on a piece of the string and the wire.

6. Cut two pieces each of the wire and the string to identical lengths of approximately 2 cm.

   (a) Place 1 piece of the string and 1 piece of the wire into test tubes containing 3-5 ml. of water.

   (b) Place the remaining samples of string and wire into test tubes containing 3-5 ml. of nitric acid (HNO_3). CAUTION! Nitric acid burns skin and clothing. Any spot that is spilled should be immediately washed with water.



7. Tie a 1 foot length of string to the center of a 6 cm length of wire. Suspend the wire, by means of the string, over the hottest part of the Bunsen burner flame for several minutes as shown in the diagram.

Observe what happens to the wire and the string.

QUESTIONS:

1. Identify 6 ways in which all kinds of matter are alike?

________ ________ ________

________ ________ ________

2. What name do we give to those characteristics in which all matter have in common?

____

3. What name is given to those characteristics which are unique to different kinds of matter?

____

Are these characteristics of matter referred to in No. 3 dependable and stable under different conditions?

4. Identify two ways in which these characteristics of matter are useful.

a) ________

b) ________

5. Give an example of a special chemical property of matter.

____

6. Give an example of a special physical property of matter.

____

Physical Quantities and the Properties of Matter

All physical objects have certain properties. Whenever we attempt to learn something about a particular object, or describe it for another person, we find that it is necessary to identify its various properties and even make measurements which may be used to describe these properties in a quantitative way.

All objects have some properties in common. For example, all objects have weight and we can make measurements of their weight. We may find that object "A" weighs 50 grams and object "B" weighs 100 grams. Since all objects have weight, the fact that object "B" weighs twice as much as object "A" does not tell us very much about either object.

Those properties of matter, such as weight, which all matter have in common, are called "General Properties."

We know from experience that all objects are not the same. Every object differs from every other object in certain special ways. The properties which make one object different from another are called "Special Properties."

The special properties of matter are of great interest. When we understand the special properties of a certain kind of matter we can use the properties of this material to our advantage. For example, understanding some of the special properties of whole blood lead to an understanding of ways and means of preparing and storing blood plasma.

In addition to the fact that it is an understanding of special properties that makes any object useful, the special properties also make it possible to describe any object with enough detail to permit another person to easily identify it.

Consider again our objects "A" and "B". Assume that both objects, "A" weighing 50 grams and "B" weighing 100 grams, are fastened to a table top. You are asked to identify which object is "A" and which is "B". With the amount of information you have about the properties of the two objects this would be impossible. Now let us assume that you also knew that object "A" was round and "B" was square. With this additional information even a blind person could identify the objects. Do you see how valuable this information about just one special property becomes?

Of course, many other special properties could be identified and each would serve to show more ways in which the objects could be described. Object "A" might be orange in color, smell sweet, and contain seeds where as object "B" might be black in color, odorless, and a solid object. This additional information about the objects still may not tell you enough to know exactly what each object is or what each might be good for, but certainly it is helpful in making a positive distinction between one and the other.

As we learn more about the special properties of any object we are in a better position to understand the relationships that one object has to another. A very important part of the purpose of science is to provide the ability and the opportunity to investigate the special properties of many objects within our universe.

Laboratory Problem

PHYSICAL QUANTITIES AND THE PROPERTIES OF MATTER

INTRODUCTION:

The purpose of this particular laboratory problem is to illustrate the kind of thinking and some of the techniques which we need to use in order to become familiar with the special properties of matter. It is also designed to illustrate that many properties of matter may be described in terms of physical quantities which can be measured.

We learn to associate certain "words" with specific measurable physical quantities. Words like time, weight, volume, velocity, color, and many others are familiar words which we use when describing special properties of matter which can be detected by the senses and measured.

In order that the "words" used to describe physical properties have meaning, when used to communicate ideas to others, "units values" must be assigned to them. The purpose of the units value is to indicate the system in which the quantity is measured. This is very important! For example, in talking about the average length of time that a white blood cell lives, I might tell you that it had a life expectance of 6. The numeral, 6, doesn't tell you much about the life expectancy; six what? 6 seconds? 6 minutes? 6 days? 6 hours? 6 years? or what? The units part of any quantitative description of a physical property is just as important as the numerical value.

In this laboratory problem you will be asked to identify and describe some of the more obvious physical properties of a set of solid objects.

PROBLEM:

With reference to the set of solid objects provided:

1. Identify those physical properties of the objects which you can measure.
2. Obtain numerical values for each of these properties.
3. Identify those physical properties which are common to all members of the set.
4. Try various ways of combining pairs of numerical values which you have obtained for these common properties. Determine whether there is any relationship which gives the same number for every object in the set.

Record both the number and units values for the physical quantities measured in the table provided. Calculate the values for those physical quantities which you could not measure directly.

After completing all of the measurements and calculations necessary to complete the table of data, use this data to work out parts 3 and 4 of the problem.

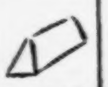
Prepare a written report of your work using the standard laboratory report form.

Include a duplicate copy of the table of data for the "Experimental Data" portion of this report.

Design a second table showing the data used in working out parts 3 and 4 of the problem for the "Analysis of Data" portion of the report.

MEASURED PHYSICAL QUANTITIES

	l	w	h	d	c	w

	l	w	h	d	c	w
						

INTERPRETATION OF DATA

	weight	surface A	volume	"k"

Area of a Sphere = $4\pi r^2$

Volume of Sphere = $4/3\pi r^3$

Area of Triangle = $\frac{b \times h}{2}$

PHYSICAL QUANTITIES AND THE PROPERTIES OF MATTER

QUESTIONS:

1. What is a general property of matter?

2. What is a special property of matter?

3. Give two reasons why special properties of matter are of great importance.

   (a)

   (b)

4. Identify 2 special properties which all of the objects in the set have in common.

5. Identify 2 special properties which are different for each object in the set.

Laboratory Problem

Name ______________________________

Science IA Hour ______

Date ______________________________

Hieros' Crown; an Inductive Problem Involving Properties of Matter

INTRODUCTION:

Archimedes (287-212 B.C.) a Greek mathematician was born at Syracuse, Sicily. As a young man he studied at the school of mathematics in Alexandria, Egypt. Archimedes acheived world fame during his lifetime not only as a mathematician but also as an inventor of machines.

On one occasion Hiero II, king of Syracuse, commanded Archimedes to determine whether the royal crown was made of pure gold. Some time afterward, while in the public bath, Archimedes observed that when his body was lowered into the tub it made the water spill over the sides. He concluded that a body immersed in water displaces an amount of water equal to its own volume, and that the apparent "loss of weight" while submerged is equal to the weight of the fluid displaced. These observations, now known as Archimedes' Principle, gave Archimedes an idea as to how he could solve the problem of analyzing Hieros' crown without damaging it in anyway. Historians have recorded that Archimedes was so excited about the idea that he jumped out of the bath and ran stark naked through the streets toward his home shouting "Eureka"! Eureka! (I have found it)

Archimedes' idea was to immerse the crown in water and to compare the volume of the water it displaced to the volume of water that would be displaced by a quantity of pure gold equal to the weight of the crown. Archimedes found that a quantity of pure gold, equal in weight to the crown, displaced less water than the crown. He reported that the crown was not pure gold and subsequently King Hiero had the goldsmith, who was a fraud, executed.

Archimedes determined that the crown of Hiero II was not pure gold but history does not tell us whether Archimedes calculated the percentage of gold present. In this laboratory problem you are faced with a problem similar to Archimedes plus the added dimension of determining the percentage composition. Your "crown" is a wooden cylinder which is not 100% wood but contains a certain % of iron metal. A second irregularly shaped piece of wood is also provided. This piece is solid wood of the same density as that in the cylinder.

PROBLEM:
1. Determine the density of the wood sample.
2. Determine the weight of the iron embedded within the wooden cylinder.

PROCEDURE:

Before attempting to gather factual information relative to the objects provided think about these problems in terms of the existing facts and what you already know about how these facts might be used to solve the problems.

(1) Establish a hypothesis for each problem. Write it down. "If such & such; then such & such".

(2) On the basis of your hypothesis determine exactly what factual information is needed to work out the hypothesis. Make a list of the factual data needed.

(3) Plan a procedure by which you intend to obtain this factual data. Write i down. (Use short sentences - do not use personal pronouns.)

(4) Organize a "data sheet" that can be used to record the factual data as it determined in the course of the investigation.

(5) Show in your "interpretation of data" how the factual data obtained was us in arriving at a solution to the problem.

QUESTIONS

1. What percent of the weight of the cylindrical object was due to the weight of the wood?

2. What percent of the volume of the cylindrical object was occupied by wood?

3. How does the "apparent weight" of a body immersed in a fluid compare to its weight in air?

4. How do you account for the fact that Hieros' crown displaced a greater volu of water than that which was displaced by a quantity of pure gold, equal in weight to the crown?

Laboratory Problem

SPECIFIC GRAVITY

INTRODUCTION:

In discussing the properties of matter it is frequently helpful, and sometimes necessary, to compare the density of one substance to that of others. In order to make such comparisons of densities useful it is necessary to choose one substance as a "Standard of Reference". When this is done the density of any substance is relative to the density of another substance. The quotient resulting from this ratio of densities is given the name "Specific Gravity".

$$\text{Specific Gravity} = \frac{\text{Density of "X" Substance}}{\text{Density of Standard}}$$

Scientists chose to use water as the standard of reference for the specific gravity of all solids and liquids. Thus the definition for specific gravity of any solid or liquid becomes:

$$\textit{Specific Gravity} = \frac{\text{Density of "X" Substance}}{\text{Density of Water}}$$

Water is an excellent choice for this standard for several reasons; among others, it is readily available all over the world and also, the density of pure water, at a given temperature, is always the same regardless of where the water comes from.

Write a definition for specific gravity in terms of the weight and volume of the "X" substance and the weight and volume of water.

If the volume of the water used in this ratio were made equal to the volume of the "X" substance, how could the equation for specific gravity be written?

PROBLEM:

1. On the basis of experimental evidence determine the specific gravity of the substances provided.
2. On the basis of your experimental results try to establish the identity of the substances for which the specific gravities have been determined.

QUESTIONS:

1. How does the density of a body in grams per cubic centimeter compare to its specific gravity? Account for this situation.
2. Suggest two reasons, other than the ones already mentioned, which point out why water is a "good" standard for specific gravity.
3. If water is used as the standard of reference for specific gravity and the density of water is 62.4 pounds per cubic foot, why is the specific gravity of water one?
4. If the specific gravity of a certain substance is 2.74, calculate the weight of one cubic foot of the material.

DENSITIES OF SELECTED SUBSTANCES

Elements

(density in g/cm³, at 20°C unless otherwise noted)

aluminum	2.699
carbon (diamond)	3.52
copper (hard drawn)	8.89
gold (compressed)	19.27
iodine	4.94
iron (rolled)	7.90
iron (steel)	7.60 7.80
lead (compressed)	11.347
mercury	13.546
platinum	21.37
silver (compressed)	10.503
tin (wrought)	7.30
uranium (13°C)	18.7
zinc (wrought)	7.19

Gases

(density in g/l, at 10°C and 760 mm pressure)

air	1.2929
ammonia	0.7710
argon	1.7837
carbon dioxide	1.9769
chlorine	3.214
helium	0.17847
hydrogen	0.08988
hydrogen chloride	1.6392
hydrogen sulfide	1.539
krypton	3.708
neon	0.90035
nitrogen	1.25055
oxygen	1.42904
radon	9.73
sulfur dioxide	2.9269
xenon	5.851

Organic Compounds

(density in g/cm³, at 20°C unless otherwise noted)

acetone	0.791
alcohol, ethyl	0.791
alcohol, methyl (0°C)	0.810
carbon disulfide (0°C)	1.293
carbon tetrachloride	1.595
glycerin (0°C)	1.260
kerosene	0.82
oil, cottonseed (16°C)	0.926
oil, linseed (15°C)	0.942
oil, olive (15°C)	0.918
oleic acid	0.898
palmitic acid	0.853
starch	1.59
stearic acid	0.849
sugar	1.59
turpentine	0.87

Woods

(density in g/cm³, oven-dry)

elm, American	0.554
fir, balsam	0.414
ironwood, black	1.077
maple, red	0.546
maple, silver	0.506
maple, sugar	0.676
oak, black	0.669
oak, red	0.657
oak, white	0.710
pine, eastern white	0.373
poplar, yellow	0.427
redwood	0.436
sycamore	0.539
walnut, black	0.562
willow, black	0.408

Miscellaneous

(density in g/cm³)

butter	0.86 0.87
brass, yellow cast	8.44
calcite	2.711
cork	0.22 0.26
diamond	3.150 3.525
flint	2.63
fluorite	3.18
glass, common	2.4 2.8
glass, flint	2.9 5.9
granite	2.64 2.76
human body	1.07
ice	0.917
limestone	2.68 2.76
marble	2.6 2.84
paraffin	0.87 0.91
quartz	2.65
sandstone	2.14 2.36
slate	2.6 3.3
water, fresh	1.00
water, sea	1.025

Skill Development

MECHANICS OF PROBLEM SOLVING

Sample Problem:

One thousand cubic centimeters of a certain liquid weighs two pounds. Calculate:

a. its density in grams per cubic centimeters

b. its specific gravity

Solutions

a.
$$D = \frac{F_w}{V}$$

$$D = \frac{\overset{1}{\cancel{2}}\ \text{lbs}}{\underset{500}{\cancel{1000}}\ \text{cm}^3} \quad \frac{454\ \text{g}}{1\ \cancel{\text{lb}}}$$

$$D = \frac{.908\text{g}}{\text{cm}^3}$$

b.
$$\text{spg} = \frac{\text{D of "X"}}{\text{D of standard } (H_2O)}$$

$$\text{spg} = \frac{.908\text{g/cm}^3}{1\ \text{g/cm}^3}$$

$$\text{spg} = \frac{.908\text{g}}{\text{cm}^3} \times \frac{\text{cm}^3}{1\ \text{g}}$$

$$\text{spg} = .908$$

Science I A

Problem Assignment:

Name ____________________

Date ______________ Hr. __

Density and Specific Gravity

**When presenting your solution to any problem organize your written work as follows:

(1) Write the equation, or principle, which applies.

(2) Show the substitution of number values and units in the equation.

(3) Solve the equation for the units answer first ! !

(4) Perform any necessary mathematical calculations on scratch paper and show the answer only on your problem sheet.

1) A cube of metal, 4 cm on a side, was found to weigh 542 g. Calculate the weight density of the metal.

2) Ten ml of a salt solution was found to weigh 11.4g. Calculate the SpG of the solution.

3) The SpG. of brass used to make laboratory weights is 8.4. Calculate the volume of brass required to make a 1 Kg weight.

4) A certain type of wood was known to have a density of $0.84 g/cm^3$. Calculate the weight of 1.6 cubic ft. of this wood.

Name ______________________

5) A cylinderical storage tank, 30 ft in diameter and 20 ft. high is filled with gasoline. The density of the gasoline is 7/10 that of water. Calculate the weight of the gasoline in the tank.

6) 420 ml of a certain liquid was found to have the same weight as 300ml of water. Calculate the specific gravity of the liquid.

7) What volume of Gold, SpG 19.3, would have the same wt as 100g of Fe, SpG 7.8?

8) A graduated cylinder contains 80 ml of water. A solid object, weighing 1.4 oz. was dropped into the cylinder and sank to the bottom. The water level in the cylinder rose to the 89.4 ml mark. Calculate the specific gravity of the object.

Review Outline

A. Hypotheses, Theories and the Process of Science

1. What is a hyposthesis?
   What are the characteristics of a hypothesis?

2. What is the difference between a hypothesis and a scientific theory?

3. What purposes does a hypothesis serve?

4. What is the value of scientific theories?

5. Distinguish between scientific theory and law. Discuss the relationship between scientific law and absolute truth.

6. Discuss the "Process of Science" as a technique of acquiring knowledge. What are its advantages? Its disadvantages?

Review Outline, Contd.

B. **Properties of Matter and Physical Quantities**

1. **What is a physical quantity?**

2. **What is the difference between a physical quantity and a physical property?**

3. **How do general properties of matter differ from special properties?**

4. **Identify 8 general properties of matter.**

5. **Discuss the relationship between density and specific gravity. Be as complete as you can.**

SKILLS TO BE TESTED:

1. **Measurement of weight by means of a triple beam balance.**
2. **Measurement of length by means of a vernier caliper.**
3. **Use of the equations defining Density and Specific Gravity.**

Sample Problems:

a) **Calculate the SpG of a substance which weighs 28.2 g and displaces 14 cm^3 when immersed completely in water.**

b) **What is the density of the substance above; in CGS, FPS units.**

c) **Calculate the weight of a steel beam which has a volume of 20.4 ft^3. The SpG of the steel is 7.8.**

d) **Calculate the volume of Magnesium, SpG 2.4 which will have the same weight as the steel beam above.**

C. Classification of Matter

Early man with his simple tools and modern man with his complex synchrotron were engaged in the same endeavor - to discover and to understand the basic substances of which all things are made.

Required Reading:	Matter, An Endless Searching For Substance, pages 12-38, 541 LSL
	Modern Chemistry, The Composition of Matter, pages 24-29
Recommended Reading:	Crucibles, The Story of Chemistry, Trevisan, p. 9-19
	"ABC's of the Elements", Science World, Nov. 9, 1960
	"The Search for New Elements", Science World, March 21, 1962

QUESTIONS FOR CONSIDERATION:

1. Solutions are a special and distinct type of mixture. Explain why this is true.
2. Why were the elements known to the ancient world, elements such as silver, gold, and sulfur rather than elements like aluminum and chlorine?
3. The discoverer of element X listed the properties of the element as these: brittle, dense, solid with a bright luster, fair conductor of heat and electricity. How would you classify this element? Explain.
4. Discuss the difference between "matter" and a "substance".
5. It has often been said that Democritus was 24 centuries ahead of his time. Would it have made any difference if Aristotle had favored the atomic theory instead of the four element theory?
6. Robert Boyle in 1661 gave the first correct definition of an element. "I mean by elements ... certain Primitive and Simple or perfectly unmingled bodies; which not being made of any other bodies, or of one another, and the Ingredients of which all those call'd perfectly mixt Bodies are immediately compounded, and into which they are ultimately resolved". Analyze Boyle's statement and write two or three sentences in modern language which state exactly what Boyle meant.
7. Why did technetium have to be "man made" when its position in the periodic table is with the naturally occuring elements?

CLASSIFICATION OF MATTER

A. Historical Concept of Matter

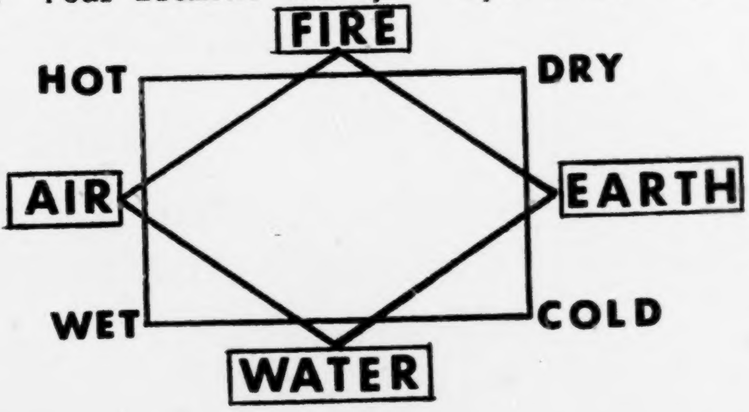
1. Greek Theories

a. Thales - 600 B.C.

b. Anaximenes - 600 B.C.

c. Heraclitus - 500 B.C.

d. Four Element Theory - Empedocles - 400 B.C.



e. Atomic Theory - Leucippus and Democritus - 400 B.C.

f. Aristotle's influence - 400 B.C. to 1600 A.D.

2. Alchemy

    a. Nature of Alchemy

    b. Goals

        (1) Elixir of Life

        (2) Universal Solvent

        (3) Transmutation of Elements

    c. Contributions

3. First Correct Recognition of an Element

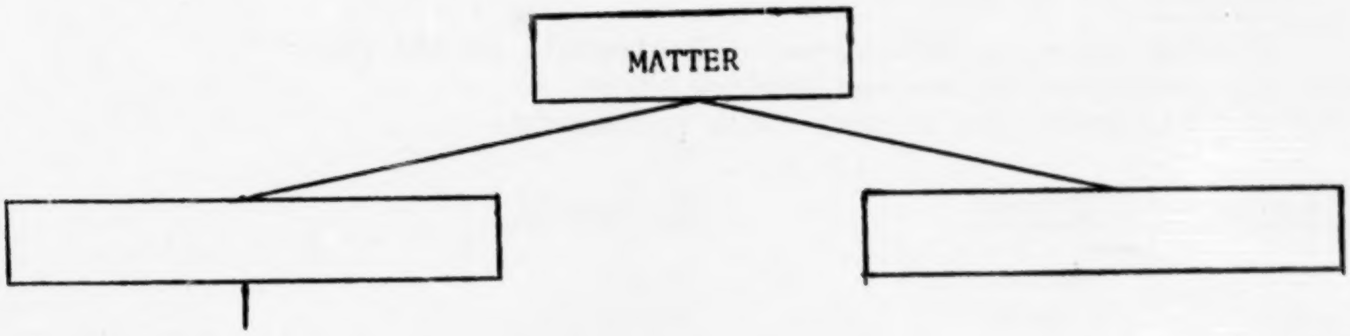
    a. Robert Boyle - definition - 1661

    b. Antoine Lavoisier - list - 1789

4. Elements Known to the Ancient World and Discovered by the Alchemists

B. Modern Concept of Matter

1. General Classification and Definitions



a. Substance

b. Element

c. Atom

d. Compound

e. Molecule

f. Mixture

g. Solution

2. Elements

a. Discovery

(1) **Natural**

(2) Man-Made

DISCOVERY OF THE ELEMENTS

Characteristics of Section One

1. Few elements discovered - 20 elements in 133 years
2. Discovery by one man working alone
3. Discovery was in many cases accidental

Year	Element	Discoverer
1669	Phosphorus	Brand
1737	Cobalt	Brandt
1748	Platinum	de Ulloa (described metal which was known earlier)
1751	Nickel	Cronstedt
1766	Hydrogen	Cavendish
1772	Nitrogen	D. Rutherford
1774	Chlorine	Scheele
1774	Oxygen	Priestley (Scheele --- publ. 1777. Bayen --- not identified)
1774	Manganese	Gahn
1781	Molybdenum	Hjelm (paper not publ. until 1790)
1783	Tellurium	Miller von Reichstein
1783	Tungsten	de Elhuyar brothers
1789	Uranium	Klaproth (as the oxide, metal isolated in 1841 by Péligot)
1789	Zirconium	Klaproth (as the oxide, metal isolated in 1824 by Berzelius)
1791	Titanium	Gregor (as oxide; oxide rediscovered and given name by Klaproth, metal isolated by Berzelius in 1825)
1794	Yttrium	Gadolin (as the impure oxide of numerous rare earths)
1797	Beryllium	Vauquelin (recognized as oxide, Wohler and Bussy independently isolated metal in 1828)
1798	Chromium	Vauquelin
1801	Niobium	Hatchett (originally named columbium)
1802	Tantalum	Ekeberg

Characteristics of Section Two

1. Elements discovered faster - 25 elements in 57 years
2. Discovery by one person working alone
3. Discovery of several elements by one person in a short time because of a new technique or tool (a breakthrough)

1803	Palladium	Wollaston
1803	Rhodium	Wollaston
1803	Cerium	Klaproth, Berzelius and Hisinger (as the impure oxide of numerous rare earths)
1804	Osmium	Tennant
1804	Iridium	Tannant
1807	Potassium	Davy
1807	Sodium	Davy

1808	Barium	Davy
1808	Strontium	Davy
1808	Caclium	Davy
1808	Magnesium	Davy
1808	Boron	Gay-Lussac and Thenard (Davy independently)
1811	Iodine	Courtois
1817	Lithium	Arfvedson
1817	Cadmium	Stromeyer
1818	Selenium	Berzelius
1824	Silicon	Berzelius
1825	Aluminum	Oersted (Wöhler isolated better sample in 1827)
1826	Bromine	Balard (Löwig isolated in 1825 but published later)
1829	Thorium	Berzelius
1830	Vanadium	Sefstrom (recognized by del Rio in 1801 but confused with Cr. metal isolated by Roscoe in 1869)
1839	Lanthanum	Mosander (as oxide, freed from didymia in 1841)
1843	Terbium	Mosander (as impure oxide; further sepn. by Marignac in 1886)
1843	Erbium	Mosander (as impure oxide containing 6 other oxides)
1844	Ruthenium	Klaus

Characteristics of Section Three

1. Discovery by two man teams
2. Several elements discovered by the same team because of a new technique or tool

1860	Cesium	Bunsen and Kirchhoff
1861	Rubidium	Bunsen and Kirchhoff
1861	Thallium	Crookes (Lamy prepared metal in 1861)
1863	Indium	Reich and Richter
1875	Gallium	Boisbaudran (Eka-Al)
1879	Holmium	Cleve (as oxide contaminated with dysprosia, spectroscopic evidence for in 1878 by Soret)
1879	Thulium	Cleve (as oxide)
1879	Scandium	Nilson (Eka-B)
1879	Ytterbium	Nilson (as oxide contaminated with lutetium)
1880	Samarium	Boisbaudran (as oxide contaminated with Gd and Eu)
1880	Gadolinium	Marignac
1885	Praseodymium	Auer von Welsbach
1885	Neodymium	Auer von Welsbach
1886	Germanium	Winkler (Eka-Si)
1886	Fluorine	Moissan (numerous earlier attempts at isolation)
1886	Dysprosium	Boisbaudran
1894	Argon	Ramsey and Rayleigh
1895	Helium	Ramsay and, independently, Cleve

1898	Krypton	Ramsay and Travers
1898	Neon	Ramsay and Travers
1898	Xenon	Ramsay and Travers
1898	Polonium	Marie Curie
1898	Radium	Marie and Pierre Curie
1899	Actinium	Debierne
1900	Radon	Dorn
1901	Europium	Demarcay
1907	Lutetium	Urbain
1917	Protactinium	Hahn and Meitner (Soddy and Cranston independently)
1923	Hafnium	Coster and Hevesy
1925	Rhenium	Noddack, Tacke, and Berg
1939	Francium	Perey
1939	Technetium	Perrier and Segre

Characteristics of Section Four

1. Elements are man-made
2. Discovery by several men working as a team of specialists
3. Discovery is difficult and only occurs when a significant breakthrough occurs

1940	Neptunium	McMillan and Abelson
1940	Astatine	Corson, Mackenzie, and Segre
1940	Plutonium	Seaborg, McMillan, Kennedy, and Wahl
1944	Americium	Seaborg, James, and Morgan
1944	Curium	Seaborg, James, and Ghiorso
1945	Promethium	Marinsky and Glendenin
1949	Berkelium	Thompson, Ghiorso, and Seaborg
1949	Californium	Thompson, Street, Ghiorso, and Seaborg
1954	Einsteinium	Ghiorso, Thompson, Higgins, Seaborg, Studier, Fields, Fried, Diamond, Mech, Pyle, Huizenga, Hirsch, Manning, Browne, Smith, Spence
1954	Fermium	
1955	Mendelevium	Ghiorso, Harvey, Choppin, Thompson, and Seaborg
1958	Element 102[1]	Ghiorso, Sikkeland, Walton, and Seaborg
1961	Lawrentium	Ghiorso, Sikkeland, Larsh, and Latimer

---

[1] Claims made for the discovery of this element in 1957 by a group from Argonne, Harwell, and the Nobel Institute were not substantiated but their suggested name, nobelium, has had considerable use. A Russian team made discovery claims in 1958.

b. Organization - Periodic Chart

c. Occurrence
  - (1) Elements in Earth's Crust
  - (2) Elements in the Universe
  - (3) Elements in the Human Body

d. Classification and Properties of Elements
  - (1) State of Matter
  - (2) Specific Properties
    - (a) Metals
    - (b) Non-Metals
    - (c) Metalloids

e. Demonstration of the Elements
  - (1) Color Slides
  - (2) Common Elements

f. Naming of Elements

(1) Ancient Names

(2) Recently Discovered Metals

(3) Recently Discovered Non-Metals

g. Chemical Symbols

(1) Ancient Symbols

(a) Pre-Dalton

(b) Dalton

(c) Berzelius

(2) Modern Symbols

(a) Significance of a Symbol

(b) Rules for Writing Symbols

(c) Universality of the Symbol

NAMES AND SYMBOLS OF THE COMMON ELEMENTS

Name	Symbol	Name	Symbol
Aluminum	Al	Lead	Pb
Antimony	Sb	Lithium	Li
Argon	Ar	Magnesium	Mg
Arsenic	As	Manganese	Mn
Barium	Ba	Mercury	Hg
Beryllium	Be	Molybdenum	Mo
Bismuth	Bi	Neon	Ne
Boron	B	Nickel	Ni
Bromine	Br	Nitrogen	N
Cadmium	Cd	Oxygen	O
Calcium	Ca	Phosphorus	P
Carbon	C	Platinum	Pt
Cesium	Cs	Potassium	K
Chlorine	Cl	Radium	Ra
Chromium	Cr	Rubidium	Rb
Cobalt	Co	Silicon	Si
Copper	Cu	Silver	Ag
Fluorine	F	Sodium	Na
Francium	Fr	Strontium	Sr
Gold	Au	Sulfur	S
Helium	He	Tin	Sn
Hydrogen	H	Titanium	Ti
Iodine	I	Tungsten	W
Iron	Fe	Uranium	U
Krypton	Kr	Zinc	Zn

CARE OF LABORATORY EQUIPMENT

1. Glass
   a. Soft glass
   b. Pyrex
2. Porcelain
3. Wood
4. Plastic
5. Rubber
6. Bristles
7. Metal
8. Asbestos

GENERAL NOTES

Laboratory Investigation

ELEMENTS, MIXTURES AND COMPOUNDS

GENERAL PURPOSE:

To study the characteristic properties of the three classes of matter -- elements, mixtures, and compounds, and to study the differences between mixtures and compounds.

PROCEDURE:

1. Place one spatula of iron filings on a small square of paper. Test the effect of a magnet on the iron. Repeat this operation using about the same quantity of powdered sulfur on a separate square of paper. Save these chemicals for Procedure 2.
2. Place the iron filings from Procedure 1 in one small test tube and the powdered sulfur in another. Fill each tube half full with carbon disulfide (CS_2), cover with your thumb and shake gently. CAUTION: Carbon disulfide is very flammable. It must be kept away from open flames.
3. Make a mixture of iron and sulfur by using a spatula of each element. Make a second mixture with one spatula of iron and two of sulfur. Separate the elements in the two mixtures by two different methods, using one method on one mixture and another method on the second mixture. The iron and sulfur should be recovered separately in each case.
4. Using the special procedure for weighing chemicals, weigh out .700 grams of powdered iron on a small square of paper. (If a dial-o-gram balance is used the weight will be .70 grams). Weigh out approximately 1.5 gram of powdered sulfur on the paper containing the iron. The weight of sulfur need not be known accurately since some of it will burn off. Mix the iron and sulfur very thoroughly with the spatula. Pat the mixture into a thin disc about the size of a quarter. Place the paper containing the disc on a wire gauze on the ring. Holding the burner in your hand light one corner of the paper and burn the paper up to the edge of the disc. If the reaction does not start immediately hold the tip of the blue cone at the edge of the disc until a glow is noticed. Remove the flame as soon as the reaction starts. When the reaction is finished, place burner under disc and heat at red heat for five minutes or until all the excess sulfur has burned off. Allow the disc to cool, carefully transfer to another square paper and weigh. Record the following weights:

   Final Weight of Compound _____ g.

   Weight of Iron in Compound _____ g.

   Weight of Sulfur in Compound _____ g.
   (Wt. Compound - Wt. Iron)
5. Prove by two different methods that you have actually made a new substance with properties different from the original iron and sulfur. Keep the disc in one piece as you try out these methods.

QUESTIONS:

1. List at least two special physical properties of the element iron and two special physical properties of the element sulfur.

2. Were these special physical properties of the elements lost when the mixture was made?

3. List two special physical properties of the compound of iron and sulfur.

4. Are the special physical properties of iron and sulfur lost when the elements combine to form a compound?

5. Are definite proportions as measured by weight required to make a mixture?

6. Are the elements in a compound present in a definite proportion by weight? (Base your answer on evidence obtained by comparing the amount of sulfur combined with .700 grams of iron in your experiment with the data obtained by other members of the class. Allow for experimental error.)

7. Compare the ease with which the components (in this case elements) of the mixture can be separated to the ease with which the components of the compound can be separated.

8. Do mixtures or do compounds most frequently involve noticeable heat and light when they are prepared?

9. Summarize the differences between a mixture and a compound. List at least three difference.

10. The ratio of the weight of the iron atom to the weight of the sulfur atom is 7 to 4. By considering this fact and the weights of iron and sulfur which combined to make the compound predict the correct chemical formula for the compound which you made and write the chemical equation for its formation.

Review

CLASSIFICATION OF MATTER

1. Name a contribution or idea for which each of the following men is known:
    - A. Robert Boyle
    - B. Thales
    - C. Democritus
    - D. Heraclitus
    - E. Anaximenes
    - F. Empedocles
    - G. Leucippus
    - H. Seaborg
    - I. Aristotle
    - J. Lucretius
    - K. Berzelius
    - L. Dalton
2. List at least two goals of the alchemists and two contributions which they made to science.
3. Why were sodium and potassium elements not known to the ancient world?
4. What four trends are noticed as the discovery of the elements is studied in chronological order?
5. Define the following words:
    - A. heterogeneous
    - B. substance
    - C. element
    - D. compound
    - E. solution

F. atom

G. molecule

6. Why were picture symbols a poor way of representing the chemical elements?

7. List four differences between mixtures and compounds.

8. Give at least four differences between metals and non-metals.

9. What is a metalloid? Name an element that is a metalloid.

10. What is meant by the "universality of the chemical symbol"?

11. What are the rules for naming recently discovered metals and non-metals?

12. Review all the symbols for the elements.

Resource Material

Basic Structure of Matter: Atoms, Molecules & Cells

A closer look at the basic structure of matter: Where did the elements come from? What is their structure? How are they different? To answer these questions, scientists must reconstruct the past and probe the energetic and uncertain ball of fluff which we call the atom.

Required Reading:	The Story of Atomic Theory and Atomic Energy, In the Beginning, 539.7 F29(L), pages 9-18
	Modern Chemistry, Atomic Theory and Atomic Structure, pages 52-58
	"The Origin of the Elements", Science World, May 15, 1963
Recommended Reading:	Matter, Mapping the Terrain of the Atom, 541 LSL, pages 119-126
	Crucibles, The Story of Chemistry, Dalton and Berzelius, pages 77-107
	"Smaller Than the Atom", Science World, March 15, 1961
	"Fundamental Particles - Children of the Atom", Science World, April 17, 1963

QUESTIONS FOR CONSIDERATION:

1. The discovery of the three fundamental subatomic particles occurred in this order: electron, proton, neutron. Give reasons why the discoveries probably occurred in this sequence.

2. Explain the meaning of the following quotation: "Although we have come to think of alchemy as no more than a fool's quest, its fundamental principle - that all kinds of matter had a common origin, that they possessed one permanent "soul", housed in a variety of temporary bodies, and that these bodies could be transmuted from one to another - bears a resemblance to the concept of unity of matter held in science today."

3. Scientists find that separation of isotopes is a difficult matter, one of the more famous examples being the separation of uranium isotopes in the production of the first atomic bomb. On the basis of the structure of isotopes and their physical properties why is separation difficult and suggest some methods by which one can accomplish this.

4. What does transmutation mean?

5. Scientists now can state with some confidence that no more natural elements will ever be discovered between hydrogen and uranium. Why is this true?

Basic Structure of Matter: Atoms, Molecules and Cells

I. Historical Development

A. Early atomic theories

1. Greek

(a) Origin of the word "atom"

(b) Leucippus and Democritus - 400 B.C.

(c) Lucretius

2. Newton and others

B. Dalton

1. Background

2. Basic concepts of Dalton's theory

(a) Concept of an atom - size and weight

(b) Symbolism

(c) Relative weights

(d) Statement of the Atomic Theory

C. Early theories of atomic structure

1. Lord Kelvin - 1867

2. Thomson - 1898

3. Lenard - 1903

4. Nagaoka - 1904

5. Rutherford - 1911

6. Bohr - 1913

II. Atomic Structure - Modern

A. Overall structure

1. Nucleus

2. Elliptical electron orbits, shells or energy levels

B. Size of an atom

1. Diameter of the atom and its nucleus

2. Weight in the nucleus

3. Visual evidence for the existence of atoms

C. Detailed structure

1. Basic subatomic particles

    (a) name and symbol

    (b) charge

    (c) location in the atom

    (d) discovery
        (1) discoverer
        (2) date

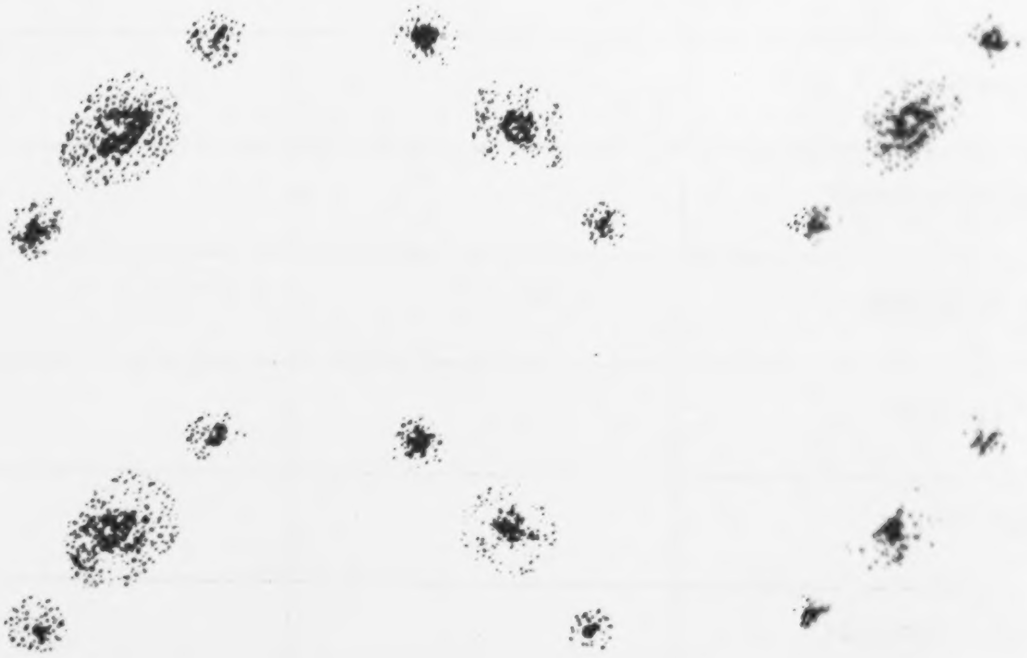
    (e) weight
        (1) grams
        (2) amu - definition of the amu

        (3) mass number

    (f) relative diameter

Name	proton	neutron	electron
Symbol			
Charge			
Location in the atom			
Discoverer			
Date of discovery			
Weight in grams			
Weight in amu			
Mass number			
Relative diameter			

X-RAY PHOTO OF HEXAMETHYLBEZENE MOLECULE. ATTACHED TO EACH INNER CARBON ATOM IS ONE CARBON AND THREE HYDROGEN ATOMS, BUT HYDROGEN ATOMS DO NOT SHOW UP. (Magnification x 40 million.)



FIELD ION MICROSCOPE PHOTO OF A PORTION OF A MARCASITE CRYSTAL
(Magnification x 25 million.)

Science IA
Problems

Name ______________________________

Science IA Hour ______

Date ______________________________

ATOMIC SIZES AND WEIGHTS

1. The diameter of the nucleus of a certain atom is 1 x 10^{-5} Å. Find the diameter of the nucleus in cm.

2. Measure the diameter of a carbon atom in the X-Ray Photo of the hexamethylbenzene molecule. Measure the diameter in centimeters using an average value. Calculate the diameter in Å. Be sure to consider the magnification given under the sketch.

3. Measure the average diameter of an iron atom and a sulfur atom in the field ion microscope photo of the marcasite crystal. Calculate both these diameters in Å.

4. Calculate your weight in a.m.u.

5. Calculate your height in Ångstrom units.

6. The weight of the nucleus of the hydrogen atom is 1 a.m.u. The volume of the nucleus is 5.22 x 10^{-40}cm^3. Calculate the density of the nuclues in g/cm^3.

7. The diameter of a "certain atom" is 4 Å. The diameter of the electron is believed to be 2 x 10^{-12}cm. How many electrons laid side by side would be necessary to reach across the atom?

Basic Structure of Matter: Atoms, Molecules and Cells

II. Atomic Structure - Modern, Contd.

2. Pattern of atomic arrangement (First 20 elements)

(a) hydrogen
    (1) atomic number

    (2) neutrality of the atom

    (3) K energy level or 1st energy level

    (4) electron cloud motion

    (5) atomic weight

    (6) isotopic symbol

(b) helium
    (1) review of above terms

    (2) orbital

    (3) electron pair

(c) lithium
    (1) review of above terms

    (2) L energy level

(d) beryllium

(e) boron
    (1) sublevel

    (2) sublevel notation

(f) carbon

(g) nitrogen

(h) oxygen

(i) flourine

(j) neon
    (1) octet

    (2) inert gas

(k) sodium

(l) magnesium

(m) aluminum

(n) silicon

(o) phosphorus

(p) sulfur

(q) chlorine

(r) argon

(s) potassium

(t) calcium

3. The kernel of the atom and the electron dot symbol

Problems

Name ______________________

Science IA Hour _______

Date ______________________

Atomic Structure Problems

1. Sketch the atoms which are represented by the following information.

   a) atomic number = 15
      atomic weight = 31 a.m.u.

   b) total number of electrons = 11
      number of neutrons = 12

   c) total number of electrons = 6
      atomic weight = 12 a.m.u.

   d) number of neutrons = 16
      number of electrons in M orbit = 6

   e) number of neutrons = 20
      atomic weight = 39 a.m.u.

   f) number of protons = 12
      atomic weight = 24 a.m.u.

   g) number of electrons in L orbit = 1
      atomic weight = 7 a.m.u.

2. Sketch the atoms which are represented by the following isotopic symbols:

   a) $^{19}_{9}X$ b) $^{28}_{14}X$ c) $^{40}_{18}X$

3. An atom has one electron in the K orbit and no neutrons. What is the weight of this atom in a.m.u. What is the name of this atom?

4. Element X has the following electron dot symbol. The outer orbit is the M orbit. The atomic weight is 27 a.m.u. Sketch Element X. $\cdot\dot{X}\cdot$

5. An element has an atomic number of 17 and an atomic weight of 35 a.m.u. Sketch the electron dot symbol for this atom.

6. The diameter of the hydrogen atom is 1 Å. Calculate the number of revolutions which the electron must make per second in the K orbit. Assume that the K orbit is circular and that the electron travels at the speed of light which is 3×10^{10} cm/sec.

4. Relative Atomic Weights

   (a) Dalton

   (b) Berzelius - 1814

      (1) reasons for the choice of oxygen as a standard

      (2) reasons for the choice of 16.0000 as a standard

5. Isotopes

   (a) Historical Development

   (b) Definition and Sketches

   (c) Isotopic Mixtures and the Atomic Weights

6. The Carbon Standard

7. The Molecule as a Structural Unit
    - (a) Definition
    - (b) Elemental Molecules
        - (1) monatomic
        - (2) diatomic
    - (c) Molecules of Compounds
    - (d) Size of Molecules
    - (e) Properties of Molecules
    - (f) Molecules in Non-Living Things
    - (g) Molecules in Living Things

Man's Ideas About the Organizational Structure of Living Matter

I Models Developed by Man to Represent his Understanding of the Nature of Matter.

A. The Atom

1. definition

2. ideas associated with the atomic theory

a)

b)

c)

d)

B. The Molecule

1. definition

2. ideas associated with the Molecular Theory.

a)

b)

c)

d)

C. The Cell

   1. definition

II Historical Development of Man's Ideas about the Nature of Living Matter.

   A. The beginnings in Greek Culture

      1. 500 BC; The Anatomy of Organisms

      2. The Influence of Aristotle

         a) Aristotle's method of inquiry

         b) Aristotelian Ideas about the Nature of Living Organisms

            (1) "A History of Animals"

            (2) "On the Parts of Animals"

         c) The development of Anatomical science

B. The Period of Roman Influence

1. Practical Anatomists

2. The investigations of Galen (130-200 AD)

3. The fall of Rome and the time of
(400-1000 AD)

4. The preservation of Galen's writings by the Moslems

C. 16th C; The Authority of Galen challenged

1. Andreas Visalius (1514-1565)

a) the conflict of ideas

b) Fabrica (1543) anatomy text book

2. William Harvey (1578-1657) Structure & Function

D. 1500 - 1850 - The Period of Exploration and Discovery

1. the extension of anatomical studies to include plants and animals

2. the beginning of specialization in the scientific inquiry of living matter.

E. The 17th C and the advent of microscopic investigations.

1. Macello Malpighi (mahl-PEE-gee) (1628-1694)

2. Nehemiah Grew (1641-1712)

3. Jan Swammerdam (1637-1680)

4. Anton van Leeuwenhoek (1632-1723)

5. Robert Hooke (1635-1703)

F. Francois Bichat (1771-1802) The concept of Substructure in Living Matter

G. Dutrochet (1824) The Concept of cellular structure

III The development of the cell theory

A. characteristics of cells

Laboratory Investigation

The Nature of Cells

The cell is a basic structural unit characteristic of all living things. Although cells vary significantly in terms of structure and function they have certain common structural and functional similarities. In this laboratory investigation you will have the opportunity to use a compound microscope to study the composition of a variety of cell structures representing both plants and animals. Some of the cells will be living,others will be taken from various plant and animal tissues.

PURPOSE:

Your purpose in this investigation is to make a careful study of each of the types of cells provided in an effort to learn as much as possible about the nature of cells.

Try to discover ways in which cells are alike or perhaps ways in which they differ. Make careful observations of such things as shape, size, color, interior structure, and evidence of activity.

For each of the nine varieties of cells provided select one cell, as seen in the high power field of your microscope, and sketch that cell in the space provided in your laboratory investigation report sheet.

Measure the diameter (or length) of that cell in microns and make a record of that measurement in the space provided. Compare the actual size of the cell you have observed to the size of your sketch of the cell and determine the magnification number for your sketch.

Some of the structural features of certain cells can be highlighted by staining techniques. If certain parts of a cell absorb a stain while other parts do not a contrast between these areas may reveal certain features that might otherwise be overlooked. You may wish to try different staining techniques in the course of your investigation.

After you have completed your study of the cells provided make a list of the cell characteristics you have observed. In light of these observations prepare a number of statements which summarize your ideas about the nature of cells.

Laboratory Investigation Report

Name ______________________

Science I___ Hour _______

Date Due______________________

THE NATURE OF CELLS

Algal Cells

cell size ________

Mag # ________ X

Onion Cells

cell size ________

Mag # ________X

Cork Cells

cell size ________

Mag # ________X

Celery Cells

cell size ________

Mag # ________X

Protozoa

cell size ________

Mag # ________X

Cartilage Cells

cell size ________

Mag # ________X

Name ______________________

Bone Cells

cell size ________

Mag # ________ X

Blood Cells

cell size ________

Mag # ________ X

Cheek Cells

cell size ________

Mag # ________ X

SUMMARY

I. Observed characteristics of cells.

1.

2.

3.

4.

5.

II. Ideas associated with the general nature of cells (statements which represent your concept of cell theory).

1.

2.

3.

4.

5.

Exercise

Name ______________________________

Science I___ Hour _____

Date ______________________________

Relative Sizes of the Fundamental Structural Units of Matter

1. Atoms range in size from Hydrogen, with an atomic diameter of about 1 Å to uranium at 5 Å. Convert these diameters to microns and then milli microns. (1 = $1X10^3$ m)

1 Å = ____μ= ____ mμ

5 Å = ____μ= ____ mμ

Indicate the relative position of the hydrogen atom and the uranium atom on the line inside the white rectangular space on the chart shown below.

Approximate sizes of some biological objects

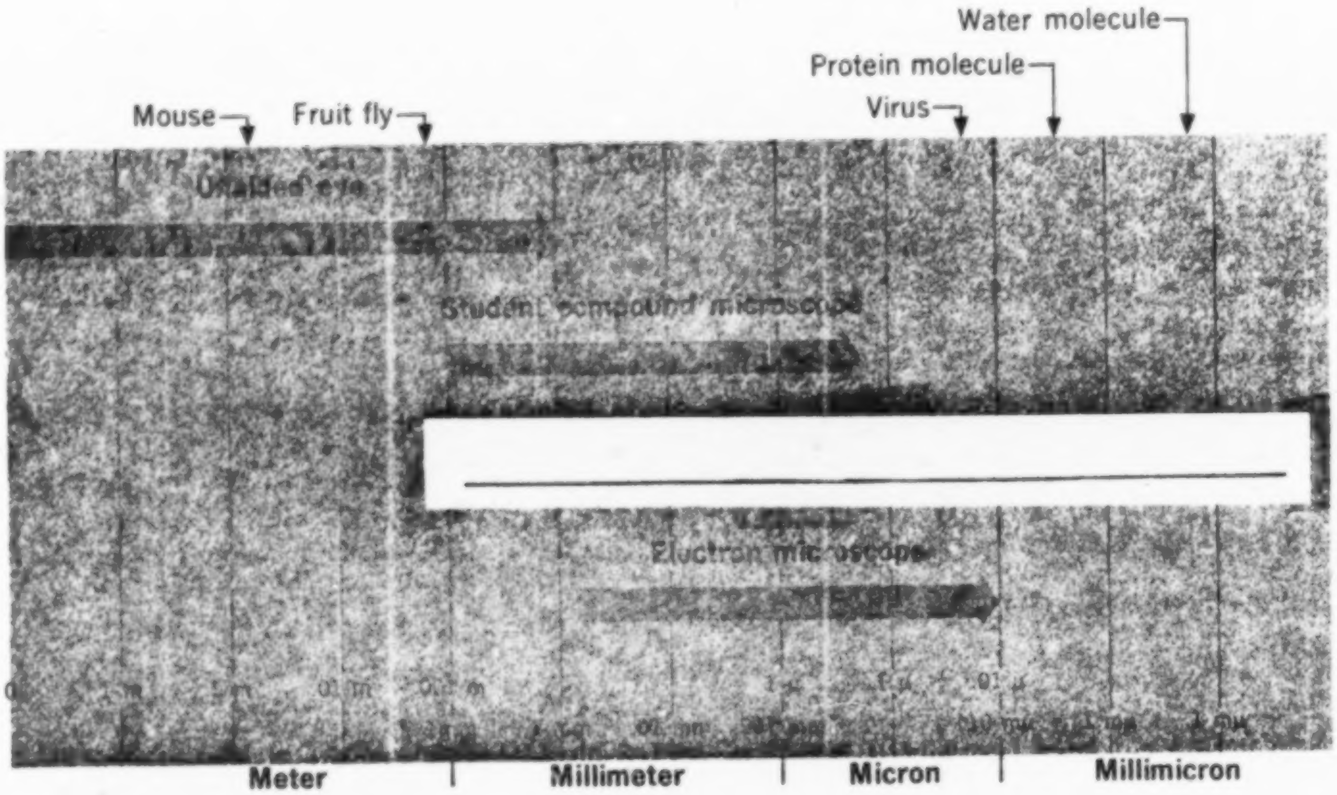


Figure 1

2. Determine the relative position of the water molgcule as shown on the chart. Calculate the diameter of the water molecule in Å based on this position

Diameter H_2O = ____mμ + __________Å

3. On the basis of your investigation of the nine different varieties of cells which of the cells you measured was the smallest? largest? Calculate the diameter or length of these cells in mm and indicate their relative position on the scale.

smallest cell ____________ dia in μ ______ = ________ mm

largest cell ____________ dia in μ ______ = ________ mm

4. The viruses represent the largest molecules yet discovered.

a) The virus is ______ times bigger than the hydrogen atom.

b) The smallest cell you observed is ______ times bigger than the hydrogen atom.

B. Basic Ideas associated with the Cell Theory

1.

2.

3.

4.

5.

6.

7.

C. The basis for the continued development of cellular structure and the nature of living things.

PERIODIC CHART

SHELLS

s

d

TRANSITION

LIGHT METALS

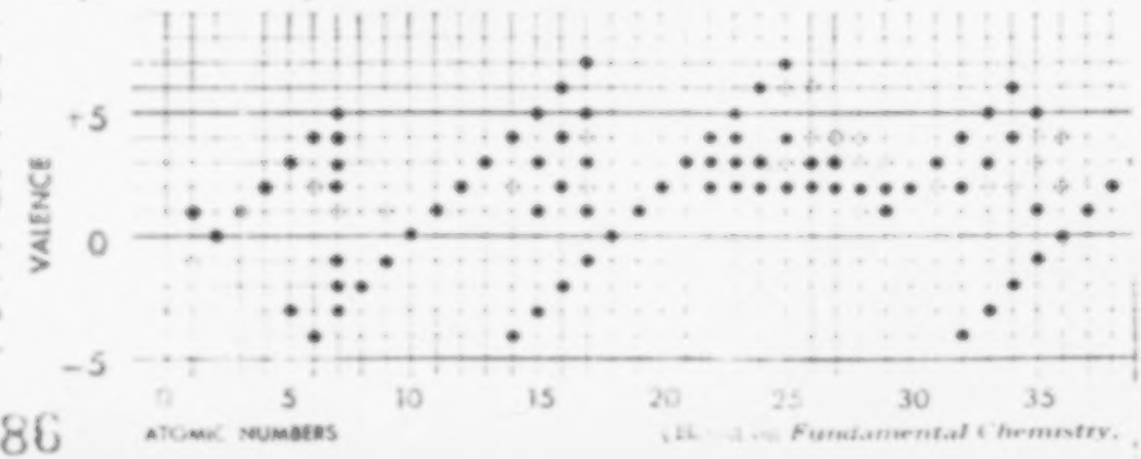
PRINCIPAL QUANTUM No. *n*	X-RAY NOTATION	I A		II A		III B		IV B		V B		VI B		VII B	
1	K	1	1 H 1.00797												
2	L	2 1	3 Li 6.939	2 2	4 Be 9.0122										
3	M	2 8 1	11 Na 22.9898	2 8 2	12 Mg 24.312										
4	N	2 8 8 1	19 K 39.102	2 8 8 2	20 Ca 40.08	2 8 9 2	21 Sc 44.956	2 8 10 2	22 Ti 47.90	2 8 11 2	23 V 50.942	2 8 13 1	24 Cr 51.996	2 8 13 2	25 Mn 54.9380
5	O	2 8 18 8 1	37 Rb 85.47	2 8 18 8 2	38 Sr 87.62	2 8 18 9 2	39 Y 88.905	2 8 18 10 2	40 Zr 91.22	2 8 18 12 1	41 Nb 92.906	2 8 18 13 1	42 Mo 95.94	2 8 18 13 2	43 Tc (99)
6	P	2 8 18 18 8 1	55 Cs 132.905	2 8 18 18 8 2	56 Ba 137.34	57-71 See Lanthanide Series		2 8 18 32 10 2	72 Hf 178.49	2 8 18 32 11 2	73 Ta 180.948	2 8 18 32 12 2	74 W 183.85	2 8 18 32 13 2	75 Re 186.2
7	Q	2 8 18 32 18 8 1	87 Fr (223)	2 8 18 32 18 8 2	88 Ra 226	89-100 See Actinide Series									

6	P	LANTHANIDE SERIES (Rare Earth Elements)
7	Q	ACTINIDE SERIES

NOTE: A value given in parentheses denotes the mass number of the isotope of the longest known half-life, or of the best known one.

*The brackets are meant to indicate only the general order of subshell filling. The filling of subshells is not completely regular as is emphasized by the use of red ink to denote shells which have electron populations different from the preceding element. In the case of He, subshell population is not by itself indicative of chemical behavior, and that element is therefore included in the inert gas group, even though helium possesses no p-electrons.

Open circles represent valence states of minor importance, or those



(B... *Fundamental Chemistry*.

OF THE ELEMENTS

REVISED, 1964

p

HEAVY METALS

NON METALS

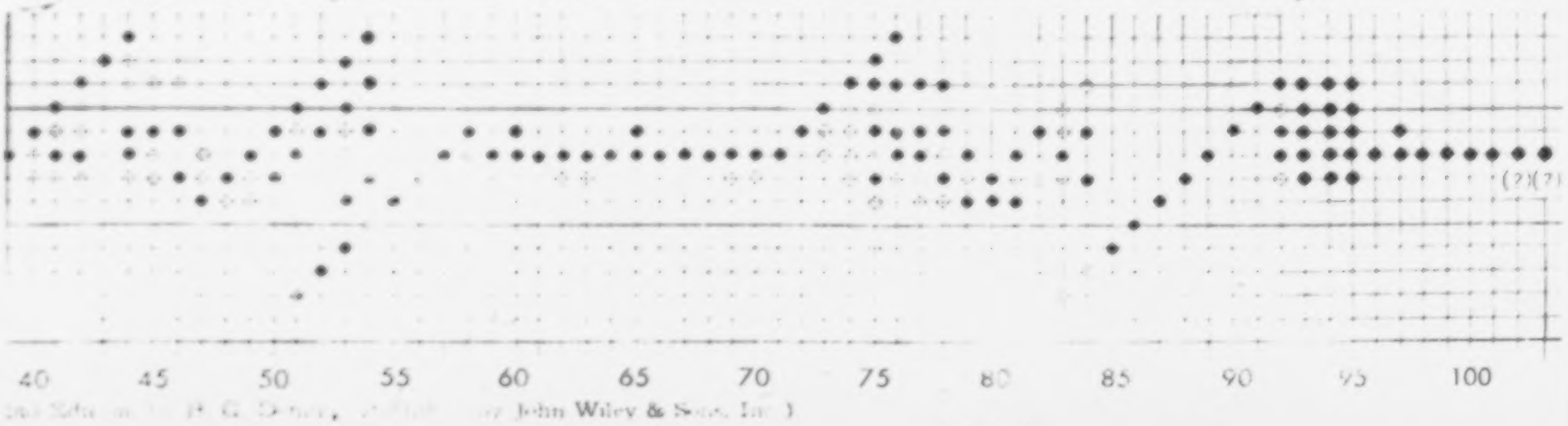
VIII	VIII	VIII	I B	II B	III A	IV A	V A	VI A	VII A	INERT GASES
										2 2 He 4.0026
					2 3 5 B 10.811	2 4 6 C 12.01115	2 5 7 N 14.0067	2 6 8 O 15.9994	2 7 9 F 18.9984	2 8 10 Ne 20.183
					2 8 3 13 Al 26.9815	2 8 4 14 Si 28.086	2 8 5 15 P 30.9738	2 8 6 16 S 32.064	2 8 7 17 Cl 35.453	2 8 8 18 Ar 39.948
2 8 14 2 26 Fe 55.847	2 8 15 2 27 Co 58.9332	2 8 16 2 28 Ni 58.71	2 8 18 1 29 Cu 63.54	2 8 18 2 30 Zn 65.37	2 8 18 3 31 Ga 69.72	2 8 18 4 32 Ge 72.59	2 8 18 5 33 As 74.9216	2 8 18 6 34 Se 78.96	2 8 18 7 35 Br 79.909	2 8 18 8 36 Kr 83.80
2 8 18 15 1 44 Ru 101.07	2 8 18 16 1 45 Rh 102.905	2 8 18 18 46 Pd 106.4	2 8 18 18 1 47 Ag 107.870	2 8 18 18 2 48 Cd 112.40	2 8 18 18 3 49 In 114.82	2 8 18 18 4 50 Sn 118.69	2 8 18 18 5 51 Sb 121.75	2 8 18 18 6 52 Te 127.60	2 8 18 18 7 53 I 126.9044	2 8 18 18 8 54 Xe 131.30
2 8 18 32 14 2 76 Os 190.2	2 8 18 32 15 2 77 Ir 192.2	2 8 18 32 17 1 78 Pt 195.09	2 8 18 32 18 1 79 Au 196.967	2 8 18 32 18 2 80 Hg 200.59	2 8 18 32 18 3 81 Tl 204.37	2 8 18 32 18 4 82 Pb 207.19	2 8 18 32 18 5 83 Bi 208.980	2 8 18 32 18 6 84 Po (210)	2 8 18 32 18 7 85 At (210)	2 8 18 32 18 8 86 Rn (222)

d

f

57 La 138.91	58 Ce 140.12	59 Pr 140.907	60 Nd 144.24	61 Pm (147)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97
89 Ac (227)	90 Th 232.038	91 Pa (231)	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (254)	103 Lw (257)

unobtainable in presence of water. For transuranian elements, all valences reported are listed.



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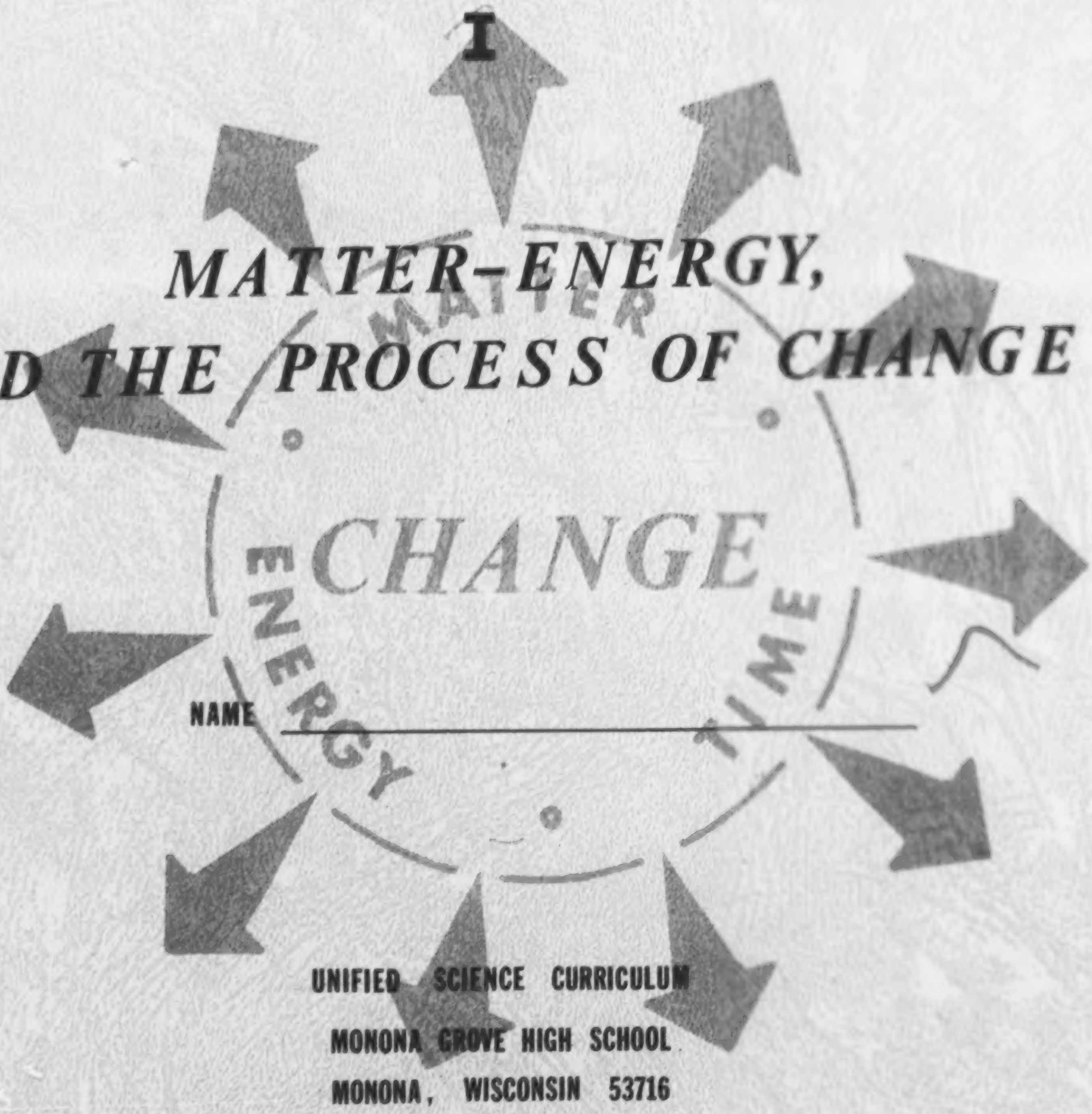
Wisconsin State Department of Education

ED 053981

SCIENCE

I

MATTER–ENERGY, AND THE PROCESS OF CHANGE

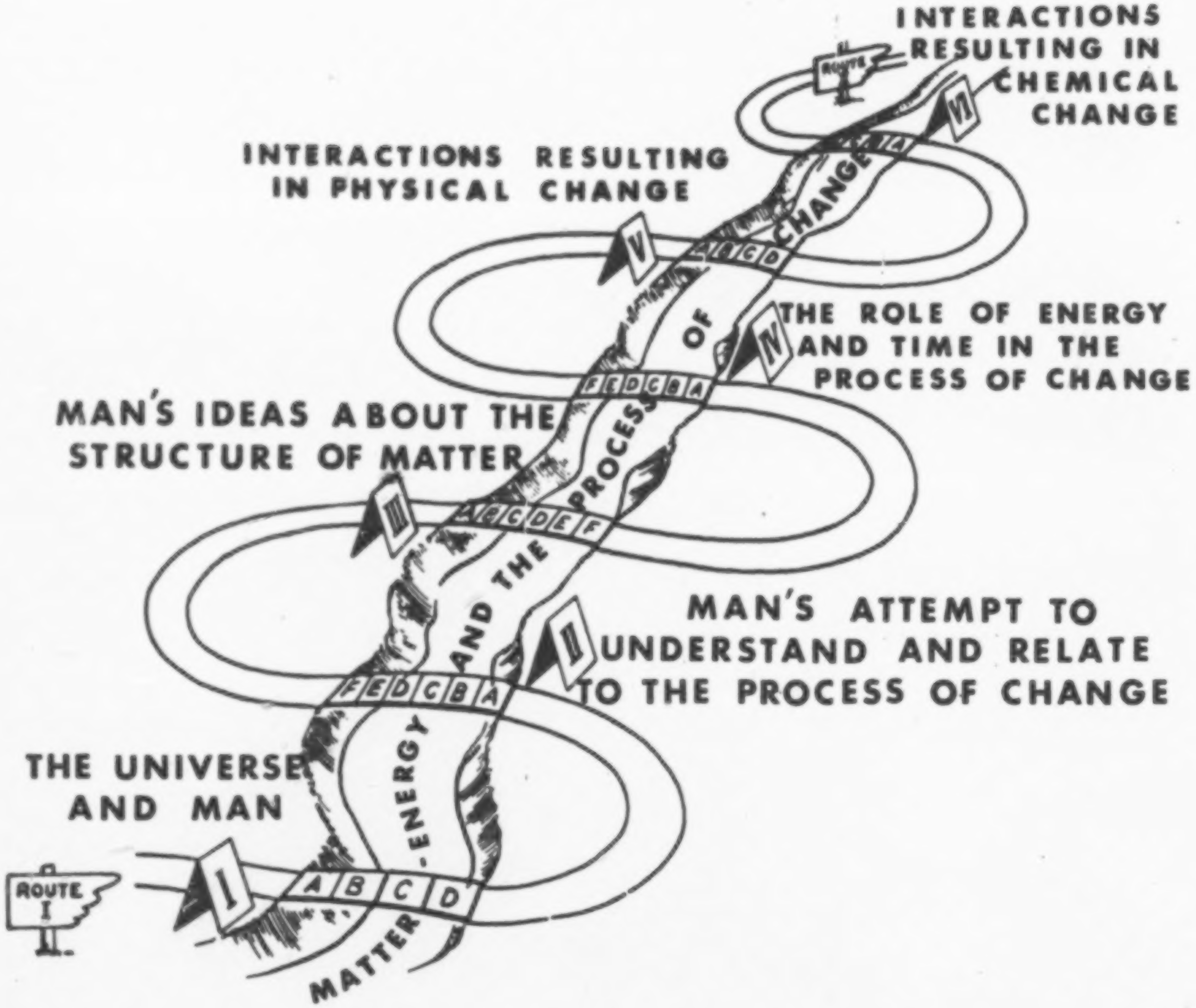


NAME ______________________________

UNIFIED SCIENCE CURRICULUM
MONONA GROVE HIGH SCHOOL
MONONA, WISCONSIN 53716

SE 012 308
Part 2

SCIENCE IA


INTERACTIONS RESULTING IN CHEMICAL CHANGE
ROUTE
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INTERACTIONS RESULTING IN PHYSICAL CHANGE
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THE ROLE OF ENERGY AND TIME IN THE PROCESS OF CHANGE
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ROUTE I
MATTER-ENERGY AND THE PROCESS OF CHANGE

III. MAN'S IDEAS ABOUT THE STRUCTURE OF MATTER

E. Particle Motion, the Kinetic State of Matter

MAN'S IDEAS ABOUT THE STRUCTURE OF MATTER

Resource Materials

Particle Motion- The Kinetic State of Matter

When we consider the special properties of different substances within our environment we find a tremendous amount of variety. Some substances are normally found as solids. They will melt and turn into gases when their temperature is raised to specific values. Other substances occur as gases. These substances may become liquids or even solids if their temperature is lowered far enough. Some liquids are very fluid at room temperature while others are very thick (viscous). Some substances are good conductors of heat and electricity while others are excellent insulators for these energy forms. Some substances are transparent to light while others are opaque.

What accounts for this great variety of properties in matter? Just what is it that gives a substance its special properties? Why is grass green? Why is water wet? Why is iron magnetic? Why does hair turn grey? These look like simple questions but the answers are not simple. To answer these "why" questions one must investigate the particle nature of matter and the ways in which it interacts with the environment.

Experience has shown that when we are faced with the problem of trying to understand or explain things which are at the time, beyond our comprehension, it is helpful to develop some sort of picture or "model" which summarizes what we do know about the problem.

How often have you found a picture or diagram helpful in working out a problem? Once a picture or model has been developed it may be used as a guide to direct our thinking into the area of the unknown. Sometimes the models we develop prove to be very satisfactory, at times we may find it necessary to revise the original model on the basis of experiences with it, in either case the model provides an opportunity to use that which we do know to learn more about that which we do not understand. This is how new knowledge is acquired. This is the Process of Science!

Required Reading:	Our Friend the Atom, "Atoms at Work", 539 H11, pages 62-70
	Audio Tape: "Models and the Process of Science"
Recommended Reading:	Challenges in Science, 525 Ja, pages 121-128

QUESTIONS FOR CONSIDERATION:

1. What are the advantages of the technique which involves the formulation of models as an aid to learning?

   Do you think that most people use this technique?

2. What are the characteristics of a "good" model?

3. Present theories as to the particle motion of molecular substances assume that the individual particles which compose the macrostructure are in constant motion.

   a. What is your understanding of the nature of this motion in the various states of matter?

   b. How is the state of matter and its subsequent particle motion related to internal energy?

   c. What kind of energy causes these particles to move?

   d. Where does this energy come from?

   e. Is the internal energy that a body contains eventually used up? If this is true where does it go? If it is not true, how do you explain the apparent continual renewal?

4. Give a word description of a model which is consistent with present experimental evidence concerning the particle nature of matter.

5. What is a molecule? Where do molecules exist?

Particle Motion - The Kinetic State of Matter

I. The Role of Models in the Process of Science

  A. What is a scientific model?

    1. The relationship between ideas and models

    2. Ways in which models may be represented

      a.

      b.

      c.

      d.

      e.

      f.

    3. Familiar models

B. The use of models

1. For what purpose are models developed?

2. What are the characteristics of a "good" model?

C. Limitations and precautions in the use of models

1. Interpretation of models

2. Confusion between models and reality

II. Development of a Mental Model (Theory) to Account for the Nature and Behavior of Molecular Substances.

Observe each of the following demonstrations very carefully. On the basis of your observations and your present understanding of the nature of matter, try to formulate a theory to explain each of the behaviors.

In conclusion you will be asked to formulate a general model to account for the structure and behavior of all molecular substances.

1. dry ice and balloon

2. alcohol - dry ice mixture and rubber tubing

3. water over copper sulfate solution

4. ammonia gas over hydrogen chloride gas

5. alcohol - water mixture

6. moth balls in solution of acetic acid and sodium bicarbonate

7. "drinking duck"

8. boats and camphor

9. sugar solution in membrane

10. potassium ferrocyanide crystal in copper sulfate solution

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The Structure and Behavior of Molecular Substances

Write a brief statement to explain the behavior observed in each of the following:

1. dry ice and balloon -

2. alcohol - dry ice mixture and rubber tubing -

3. water over copper sulfate -

4. ammonia gas over hydrogen chloride gas -

5. alcohol - water mixture -

6. moth balls in solution of acetic acid and sodium bicarbonate -

7. "drinking duck" -

8. boats and camphor -

9. sugar solution in membrane -

10. potassium ferrocyanide crystal in copper sulfate solution -

In the words of Svante Arrhenius (1859-1927), the brilliant Swedish chemist, "I have experimented enough, now I must think."

On the basis of what you have observed in the preceding actions involving molecular substances, coupled with your past experience, formulate a number of key statements which describe the major ideas associated with your mental model of molecular substances.

1.

2.

3.

4.

5.

6.

7.

A QUANTITATIVE INVESTIGATION OF PARTICLE MOTION WITH A PHYSICAL MODEL

At this particular point in our study we are confronted with the problem of developing a more complete understanding of the nature of molecular substances.

At the present time each of us has developed a personal model (idea) of what a molecular substance is like.

Suppose that we incorporate some of these ideas fundamental to our various mental models into a physical, working model and then use this device as a basis for suggesting questions to investigate.

Most everyone agrees that molecular substances are composed of separate sphere-like particles which are in constant motion. We could use familiar ping pong balls to represent these invisible particles and then cause them to move by directing a strong blast of air against them. Placing the balls in a covered container would prevent them from being scattered all over the room and would give us a chance to make some interesting observations dealing with their motion. For example, if the ping pong balls were made to move about inside a container, collisions between the balls and the side walls of the container would surely occur.

Question: What would determine how often a particular ball would experience a collision?

Would all of the balls in the container travel with the same speed?

Would the average speed of one ball be the same as the average speed of any other ball in the model?

You could probably think of many more questions to ask but these three constitute a good beginning.

PROBLEM:

How does the average speed of one ball in the ping pong ball model compare to the average speed of any other ball in the model during a period when the fan is running at constant speed?

Problem translated from the model to an actual molecular substance.

> How does the average speed of one molecule in a compound compare to the average speed of any other molecule in the same compound while the temperature of the compound is held constant?

ESTABLISHMENT OF A WORKING HYPOTHESIS:

EXPERIMENTAL DATA:

Time Interval	Number of Collision with Top Surface											
	RED			YELLOW			BLACK			GREEN		
30 sec												
1 min												
1½ min												
2 min												
3 min												
4 min												
5 min												
6 min												

INTERPRETATION OF DATA:

Summarize the experimental data graphically. Base your conclusion (answer to the problem) on your interpretation of the graph.

A QUANTITATIVE INVESTIGATION OF PARTICLE MOTION WITH A MOLECULAR MODEL

ANALYSIS OF DATA:

	time (min.)	Average Number of Collisions with Top Surface			
		RED	YELLOW	BLACK	GREEN
	½				
	1				
	1½				
	2				
	3				
	4				
	5				
	6				
(4 + 3)	7				
(5 + 3)	8				
(5 + 4)	9				
(6 + 4)	10				
(6 + 5)	11				
(3 + 4 + 5)	12				
(3 + 4 + 6)	13				
(3 + 5 + 6)	14				
(4 + 5 + 6)	15				
(6 + 5 + 3 + 2)	16				
(6 + 5 + 4 + 2)	17				
(6 + 5 + 4 + 3)	18				
(6 + 5 + 4 + 3 + 1)	19				
(6 + 5 + 4 + 3 + 2)	20				
(4 + 6 + 5 + 3 + 2 + 1)	21				
all except 1	22				
all	23				

Laboratory Problem Report

Name ______________________

Science IA Hour _______

Date ______________________

A QUANTITATIVE INVESTIGATION OF PARTICLE MOTION IN A PHYSICAL MODEL

QUESTIONS:

1. Describe the motion of one particular ball in the model, compared to any other ball in the model, after the machine has been operating, for several minutes, at constant fan speed.

2. What does a change in fan speed, in the molecular model, represent in an actual molecular substance?

3. What does the model suggest about the probable distance between actual molecules in a gaseous compound compared to the diameter of the molecule?

4. What does the model suggest about the average rate of motion of molecules in:

   (a) solids

   (b) liquids

   (c) gases

5. Explain why some balls in the model travel faster than the average speed at times and slower at others.

III. Extensions to a Kinetic Molecular Theory based on observations of particle motion in a physical model.

A. Summary discussion of particle motion in the model.

B. Temperature, energy content, and the states of matter.

C. Word description of your present concept of Kinetic Molecular Theory.

SCIENCE I

Question for Review

PARTICLE MOTION, THE KINETIC STATE OF MATTER

1. What is a scientific model?

2. Mention five different ways in which a scientific model may be developed and represented.

3. Discuss two of the purposes for which scientific models are developed.

4. Identify two different ways in which experimental data may be represented graphically. What kind of data is especially suited to each of those types of graphic interpretation?

5. Identify four advantages of representing experimental data graphically.

6. What does your mental model of an atom suggest about the structure of the atom? Identify all the ideas fundamental to your concept of an atom and atomic structure. Use a short simple statement to express each idea.

7. Write a complete description of your mental model of a molecular substance. Use a short simple sentence to express each idea.

8. Identify four fundamental differences between atoms and molecules.

9. How do you account for the fact that the average number of collisions experienced by one of the balls in our molecular model was significantly less than those of the other three balls observed?

10. Discuss the following with reference to the activity of the particles in the molecular model:

    a. the type matter represented by the 144 ping pong balls -

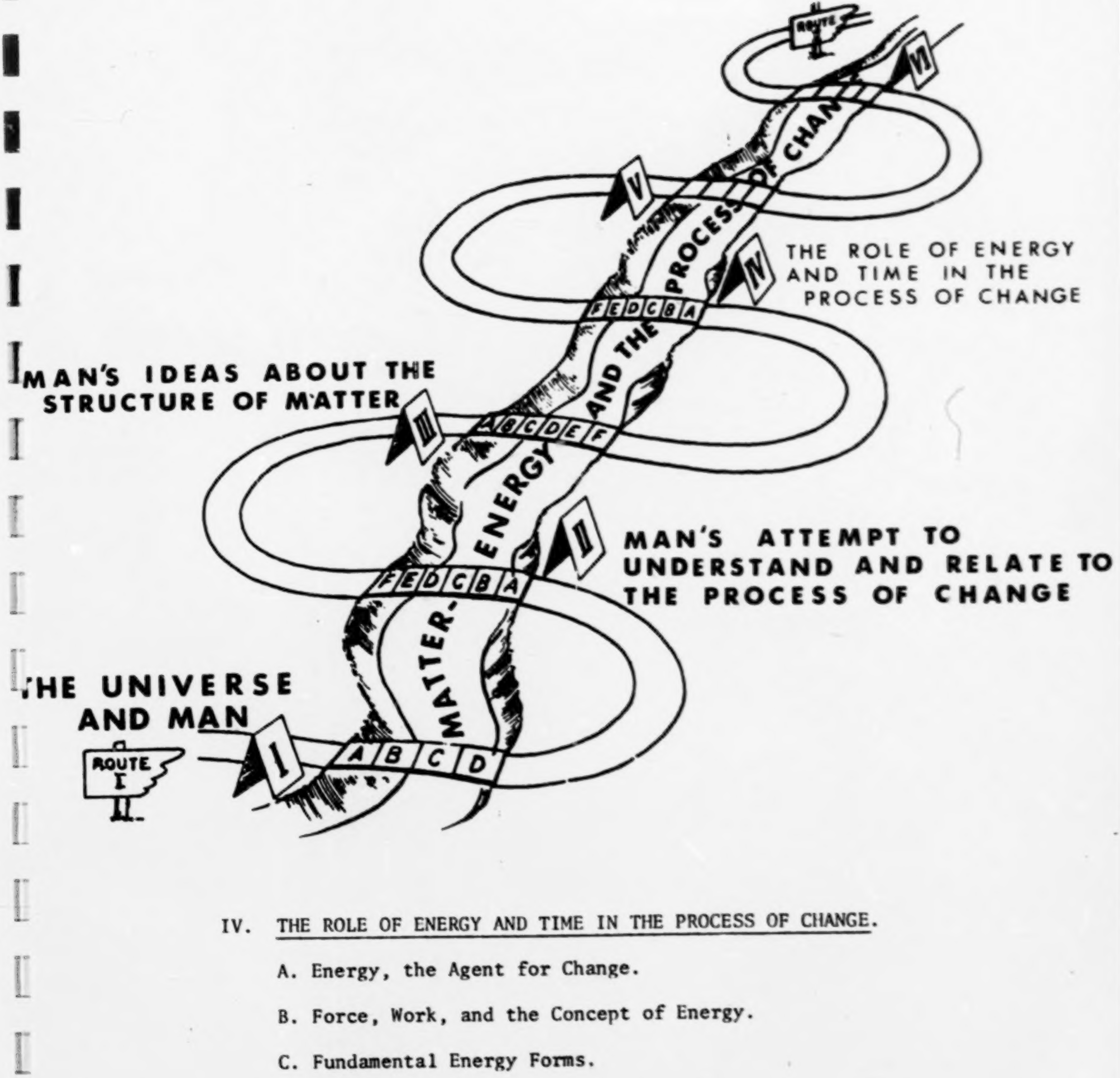
    b. the average energy possessed by the various "molecules" in the model -

    c. the average velocity of the "molecules" -

11. How is the rate of collision between gas molecules and their container affected by changes in the volume of the container? Discuss completely.

12. The density of water is one gram per cubic centimeter. Assume that one molecule of water weighs 3 x 10^{-23} grams. Calculate the volume of the water molecule.

13. If the water molecule were perfectly spherical its volume would be equal to $4/3\pi r^3$. Under the condition described above calculate the diameter of a water molecule.
    Express your answer in Å .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IV. THE ROLE OF ENERGY AND TIME IN THE PROCESS OF CHANGE.

A. Energy, the Agent for Change.

B. Force, Work, and the Concept of Energy.

C. Fundamental Energy Forms.

D. Energy, Time, and the Concept of Power.

E. Energy Resources and Their Utilization.

F. Order- Disorder and the Process of Change.

Resource Material

Energy, the Agent for Change Within the Universe

In this section our major area of concern is the Role of Energy in the Process of Change. Our purpose is to gain a more complete understanding of what energy is, the forms in which it exists, the ways in which it is stored and transferred, and the types of changes that result when matter and energy interact.

Required Reading: Energy, Life Science Library, pp 12-16

Audio Tape same title

Recommended Reading: Push and Pull, 531 B63, pp 43-54

Questions For Consideration:

1. What is energy? In what ways does Energy differ from Matter? How are matter and energy alike?

2. Can energy be measured? What is really being measured when one attempts to determine how much energy a body possesses or how much energy is being used?

3. How does the amount of energy now present on the earth compare to the amount that was present $2X10^9$ years ago? According to theories in cosmology, how does the amount of energy present in the universe now compare to the amount that was present 5 billion years ago?

4. How does energy exist in our environment, in what forms does it occur?

5. Discuss the various ways in which energy can be stored by natural process, by man made devices.

6. What is meant by the "Law of Conservation of Matter and Energy"?

ENERGY - THE AGENT FOR CHANGE

INTRODUCTION:

Energy, like force, is a word we use to describe a physical quantity familiar to all of us. Although "energy" is common place in our experience how much do we really know about it? What is energy? Where does energy come from? Where does energy go when it is used up? What is the difference between force and energy?

We know that energy is essential to life, but why is this true? We know that there are different kinds of energy, like electrical and heat and light, but just what is the difference between one form of energy and another?

In response to the question, what is energy?, most students say, "energy is the ability to do work". But, what is work? Is work the same as energy? Can a body possess energy without doing work?, or, do work without possessing energy?

Force is an undefined physical quantity. We experience it directly, we can measure it, but we cannot define it. When the wind blows against the side of our house it exerts a force against the house. Wind, which is actually air moving, is a form of energy and it exerts force.

Weight is also a force. It is a result of the attraction that the earth has for any body. This gravitational force between bodies exists whether the bodies are in motion or at rest. Apparently the force of gravity is dependent upon the quantity of matter a body possesses, not its energy.

Energy and force are related but they are not the same thing. Energy and work are related but they are not the same thing. Energy and matter are related but they are not the same thing. How are force, work, and energy related?

What is energy? - the ability to do work, anything that exists which does not have weight or take up space, force associated with moving matter. These statements are true but not very useful in helping us to really understand what energy is.

All that exists within the universe is either matter or energy. We have managed to develop a pretty clear concept of matter. We know something about its general and special properties, its structure, and its composition. Our goal now is to develop a more satisfactory concept of the nature of energy. Having accomplished this goal we will have established the ideas which are basic to an understanding of matter - energy interactions and the process of change.

ENERGY, THE AGENT FOR CHANGE

I A preliminary concept of what energy is

A. The matter - Energy relationship.

B. Energy defined in descriptive terms.

II The Natural Occuring Energy States; how energy exists in nature.

A. Kinetic Energy - "Motion Energy"

Forms of the Kinetic State

1. Mechanical Energy
    - a) macro particle
    - b) sound
    - c) electrical

2. Radiant Energy; electromagnetic radiation
    - a) heat
    - b) light
    - c) high energy radiation

II Natural Occuring Energy States, Cont.

B. Potential Energy - "Rest Energy or Stored Energy"

1. Storage of Mechanical Energy

   a) macro bodies at rest

   b) electrical

2. Storage of Radiant Energy

   a) within molecules

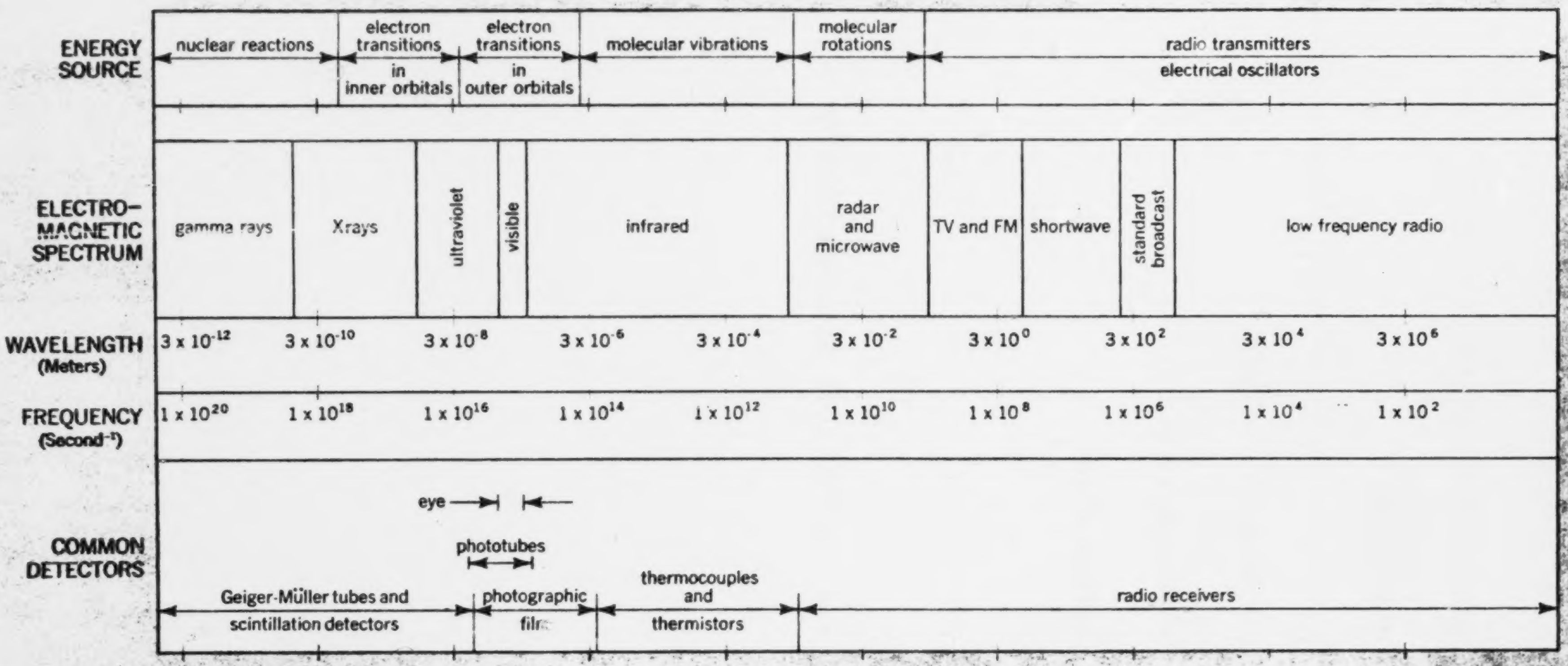
   b) within atoms

III Internal Energy and the Particle Nature of Matter

A. Kinetic

B. Potential

ELECTROMAGNETIC SPECTRUM


ENERGY SOURCE
nuclear reactions
electron transitions in inner orbitals
electron transitions in outer orbitals
molecular vibrations
molecular rotations
radio transmitters
electrical oscillators
ELECTRO-MAGNETIC SPECTRUM
gamma rays
Xrays
ultraviolet
visible
infrared
radar and microwave
TV and FM
shortwave
standard broadcast
low frequency radio
WAVELENGTH (Meters)
3 x 10-12
3 x 10-10
3 x 10-8
3 x 10-6
3 x 10-4
3 x 10-2
3 x 100
3 x 102
3 x 104
3 x 106
FREQUENCY (Second-1)
1 x 1020
1 x 1018
1 x 1016
1 x 1014
1 x 1012
1 x 1010
1 x 108
1 x 106
1 x 104
1 x 102
COMMON DETECTORS
eye
phototubes
Geiger-Müller tubes and scintillation detectors
photographic film
thermocouples and thermistors
radio receivers

Taken from "Terms, Tables, and Skills
For The Physical Science", B.J. Woodruff,
Silver Burdett Company

IV Mechanisms by which Energy is Transmitted from one Point in Space to Another.

A. Collisions between particles of matter

1. Energy Forms transmitted by collision of particles.

2. Factors associated with the quantity of energy transmitted by particle collision.

B. Wave action.

1. Types of energy waves.

a) mechanical waves

(1) longitudinal

(2) transverse

b) electromagnetic

2. Characteristics of energy waves.

    a) wave length

    b) frequency

    c) velocity

3. Energy Forms Transmitted by Wave Action.

    a) Mechanical waves

        1) longitudinal

        2) transverse

    b) Electromagnetic waves.

V Matter - Energy Relationships

A. Methods of Energy Capture and Storage.

B. Methods of Energy release

C. Equivalence between matter and energy

D. Energy transformations

1. Electrical
2. Heat
3. Light
4. Mechanical
5. Sound

Physical Quantity	Symbol	Definition	Vector	Scalar	Gravitational System		
					English	Metric	
					F.P.S.	C.G.S.	M.K.S.
LENGTH	1	undefined	x		feet	centimeters	meters
FORCE	F	undefined	x		pounds	grams	kilograms
TIME	t	undefined		x	seconds	seconds	seconds

FORCE, WORK, AND THE CONCEPT OF ENERGY

I. The Undefined Physical Quantities Associated with the Process of Change

   A.

   B.

   C.

   D.

   E.

   F.

II. Vector and Scalar Properties of Physical Quantities

   A. Vector Quantities

   B. Scalar Quantities

III. Systems and Units for the Measurement of Physical Quantities

   A. Gravitational System

      1. English (FPS)

      2. Metric System

         a. CGS

         b. MKS

   B. Absolute System

IV. Force, a Fundamental Undefined Physical Quantity

A. Examples of Forces Which Act Upon Matter

1.

2.

3.

4.

5.

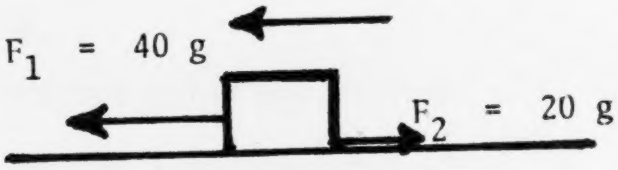
B. Detection and Measurement of Forces

1. How are forces detected?

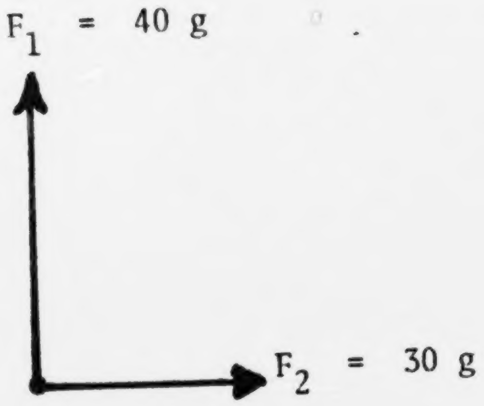
2. How are forces measured?

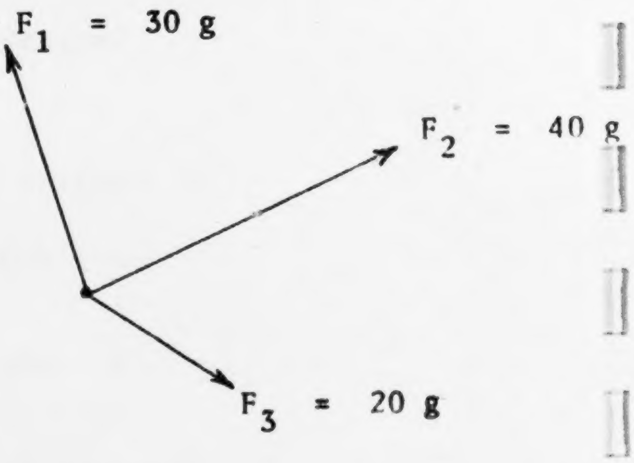
C. The Vector Addition of Forces

1. Parallel Forces


F_1 = 40 g
F_2 = 20 g

2. Non Parallel Forces


F_1 = 40 g
F_2 = 30 g


F_1 = 30 g
F_2 = 40 g
F_3 = 20 g

a. Component force

b. Resultant force

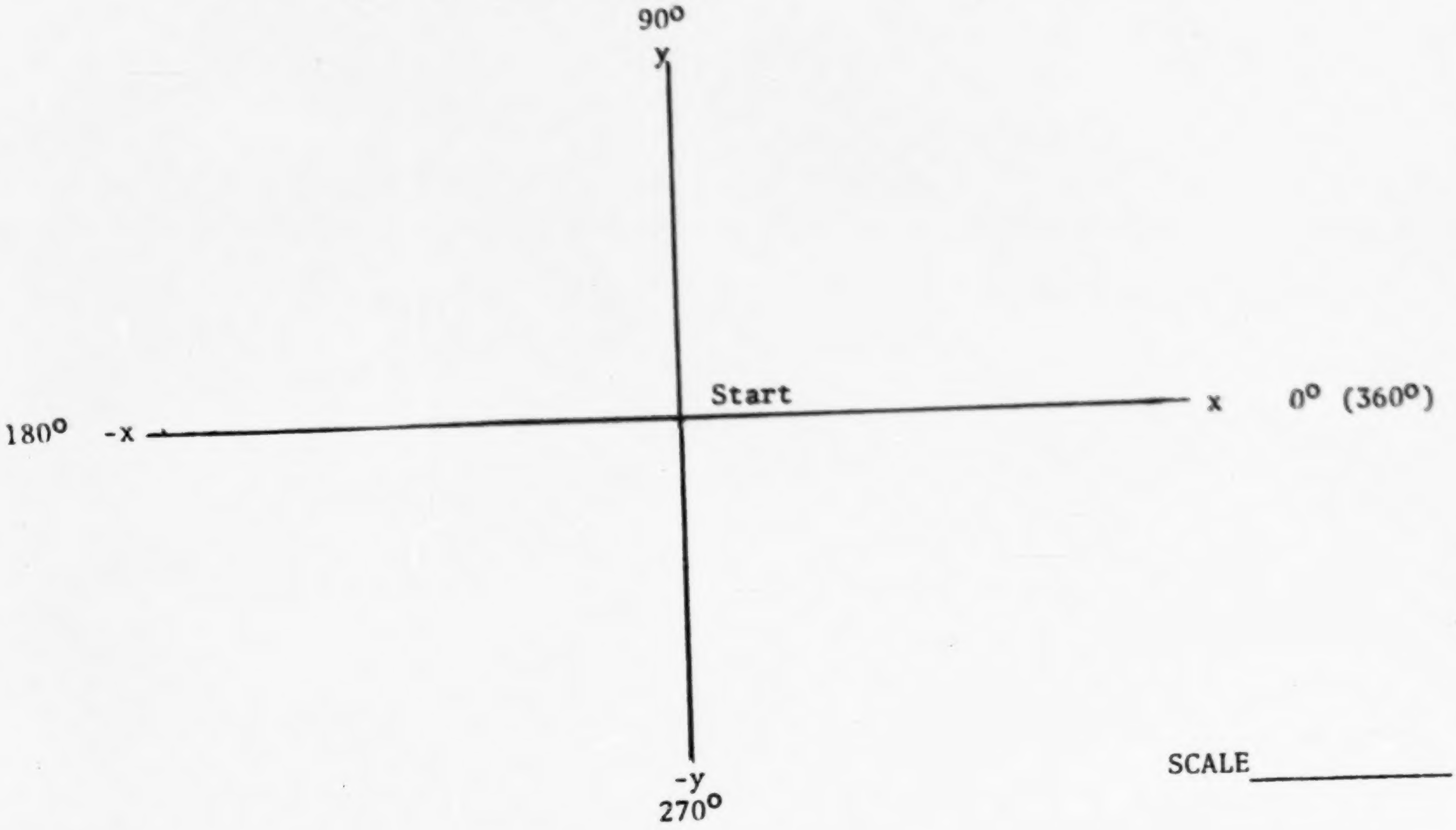
F_1 = 30 g at 106°

F_2 = 40 g at 24°

F_3 = 20 g at 326°

3. Polygon Technique for Adding Non-parallel Vector Quantities.

a) The coordinate system



SCALE____________

b) Representing the magnitude of the vector quantity

c) Representing the direction

d) Determination of the magnitude and direction of the Resultant

Exercise

Name ______________________________

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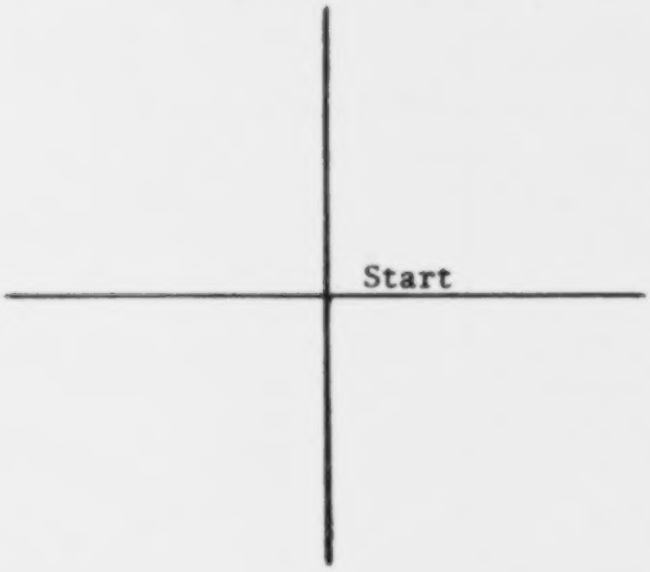
Date Due ____________________

Vector Addition of Non-parallel Forces Acting at One Point

1. Three forces act simultaneously upon a body at the same point. F_1 = 40g at 30°, F_2 = 60g at 140°, and F_3 = 50g at 190°. Determine the magnitude and direction of the resultant force.



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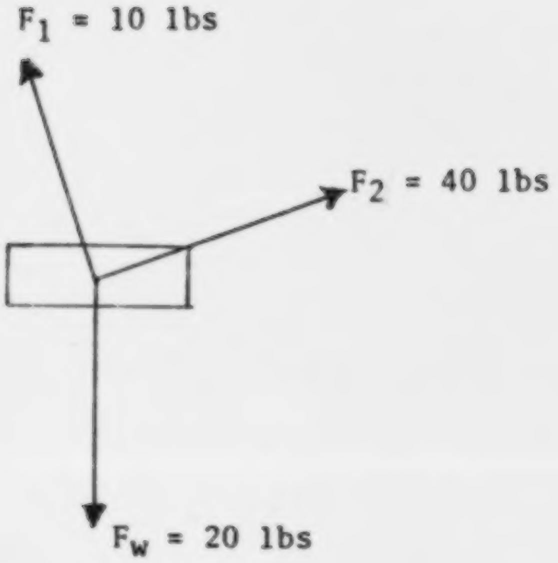
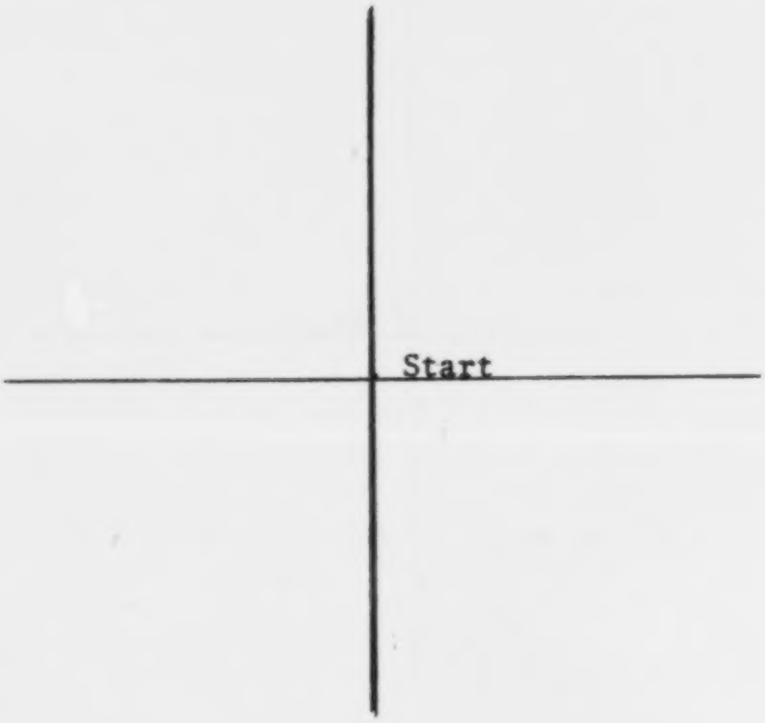
2. Determine the resultant force for the system shown below.





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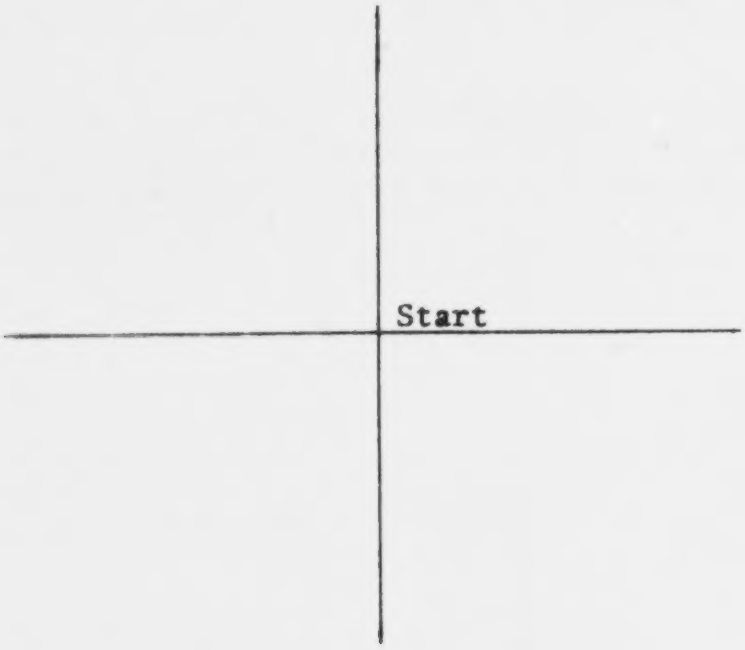
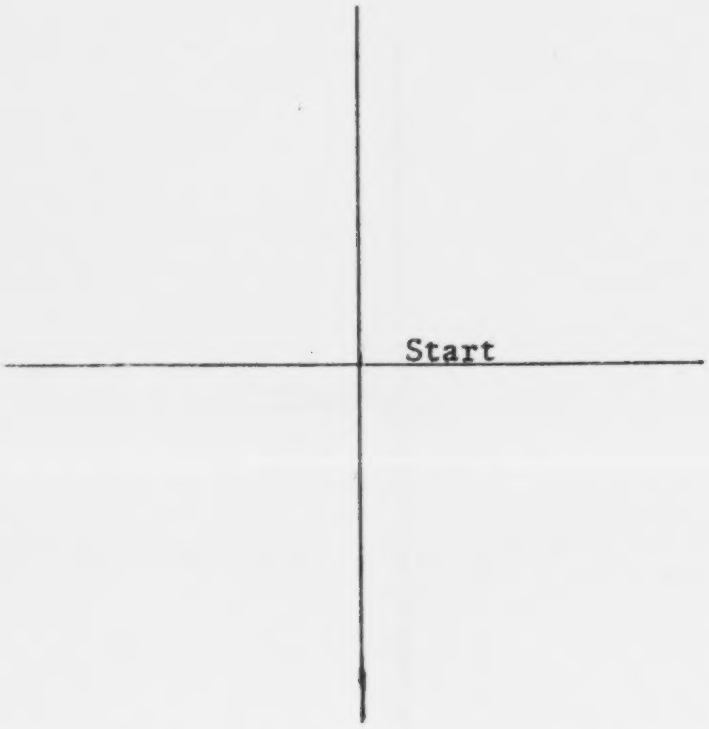
3. The following forces were found to act simultaneously upon a body. F_1 = 400g, 20° ; F_2 = 600g, 60° ; F_3 = 500g, 340° and F_4 = 1000g, 200°. Determine the resultant force.



SCALE________

4. A force of 140 lbs, 40° acts upon a body which weights 100 lbs. It is necessary that this system produce a resultant force of 10 lbs. at 180°. Calculate the magnitude and direction of a single force which will produce this condition.



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WORK - THE INDIRECT MEASURE OF ENERGY

I Conditions Required on the Physical Definition of Work.

A. The Product of Two Parallel Vector Quantities

1. Force

2. Distance

B. Work, a scalar quantity

C. Difference between "Exerting a Force" and "Doing Work"

II The Work - Energy Relationship

A. Factors which affect the Kinetic Energy Possessed by Matter

1.

2.

B. Factors which affect the Potential Energy Possessed by Matter

1.

2.

C. Equivalence between Work and Energy.

1. work done vs energy expended
2. energy gained vs work done

Laboratory Investigation

FORCE, WORK, AND THE CONCEPT OF ENERGY

INTRODUCTION:

All forms of energy are detected and measured by observing the effect that they have on matter.

Whenever energy acts upon matter, forces are involved. Although we cannot say exactly what force is, we do know that forces are exerted when energy is expended. We cannot observe energy directly but we can detect and measure the force associated with energy release.

When energy and matter interact, the quantity of energy involved in the interaction is measured in terms of the work done. Work is done whenever a force acting upon a body is able to move the body. Work is defined as the product of the force acting times the distance the body is moved. Force is a vector quantity, that is, forces have direction as well as magnitude. When any force acts upon a body it always acts in a specific direction and tends to move the body in that direction.

Sometimes forces which act upon a body in one direction cause the body to move in a different direction. For example, we have seen sailboats move in a direction perpendicular and even opposite to the direction of the force due to the wind. The forces resulting from the burning of gasoline in an automobile engine cause the pistons to move up and down, yet the auto moves forward or backward. In cases such as these more than one force is acting at the same time. These forces must be added vectorially to determine the resultant force which is responsible for the motion.

In order to avoid confusion in describing the amount of work done when a body is moved scientists define work as the product of the resultant force acting parallel to the direction a body moves, times the distances the body is moved.

work = resultant force x distance, where the RF is parallel to d

$$\boxed{w = RF \cdot d \quad (RF // d)}$$

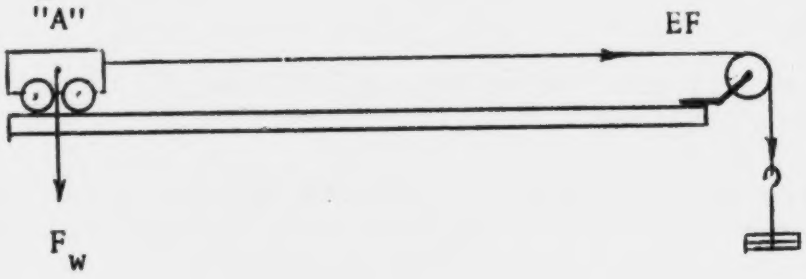
If energy expended in a system does not result in forces large enough to move the system no work is done. One could exert several hundred pounds of force against the side of a building, but, unless the force causes the building to move a measurable distance, no work is done.

Work cannot be done without expending energy. However, the expenditure of energy does not necessarily result in work being done. If the energy expended results in forces which cause matter to be moved, then work is done.

In this experiment you will expend mechanical energy to produce forces capable of moving matter. You will measure these forces and calculate the work done in moving matter through various distances.

PROCEDURES:

I. Set up a smooth board and pulley system as shown below:



1. Determine the weight of the cart A.

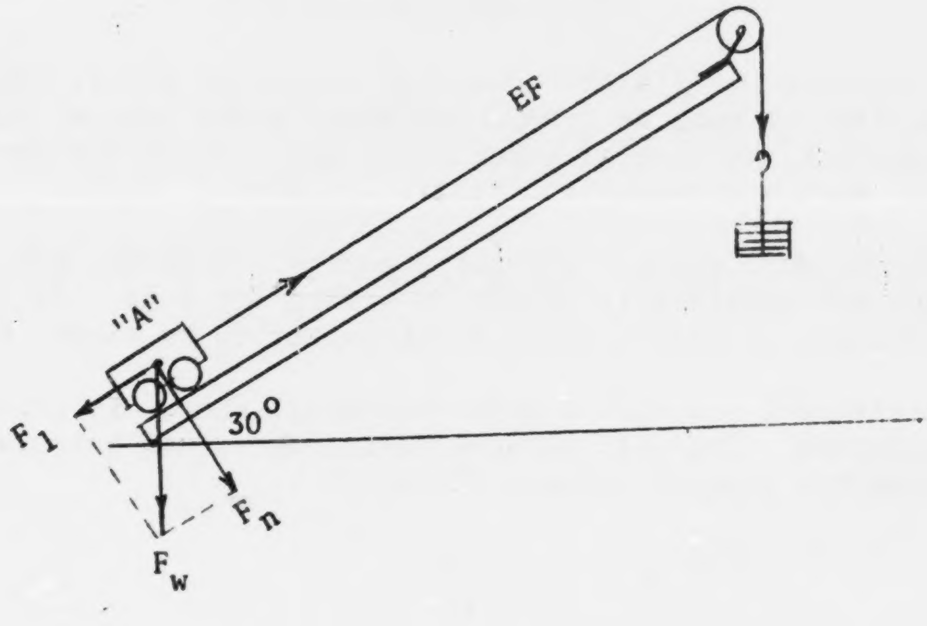
2. Determine the effort force, EF, required to slide the cart along the surface with constant speed. It will be necessary to give the cart a slight push to overcome its "rest inertia" before it will continue to move with constant speed.

3. Calculate the amount of work that would be required to move the cart 100 centimeters along the surface of the board.

4. Double the weight force which presses the cart against the surface of the board by placing the proper number of metal weights inside the cart. Now measure the EF required to move the cart (plus weights) along the board.

5. Calculate the amount of work that would be required to move the cart and weights 100 centimeters along the surface of the board.

II. Raise one end of the board so that it makes an angle of 30° with the table top (see diagram below). This means that the end of the board must be raised to a height which is exactly one-half the length of the board.



1. Measure the EF required to move the cart up the incline with constant speed.

2. Calculate the amount of work that would be required to move the cart 100 centimeters along the incline.

3. If the cart was moved from the bottom of the board, a distance of 100 centimeters along the incline, how high would the cart be from the table top?

4. How much work would be required to lift the cart vertically from the table top to this same height?

III. A. When the cart is resting on the incline the weight of the cart, which has a direction of 270°, can be represented as two component forces. One component, parallel to the incline, is the force which tends to pull the block down the incline. Call this component force F_1 your effort force, $E_F \nearrow$, prevents this from happening. The second component of the $F_w \downarrow$ is "normal" or perpendicular to the incline. This component, usually designated F_n, is the component of the weight force which tends to break the board. The vector sum of these two components is equal to the weight force. In other words $F_w \downarrow$ is the RF of $F_1 \swarrow + F_n \searrow$.

Draw a vector diagram to determine the magnitudes of F_1 and F_n when the angle of the incline = 30°.

B. Working only with F_1 and F_E which act simultaneously upon the cart in a direction parallel to its motion along the incline.
Calculate the resultant force acting upon the cart as it moves upward along the incline.

Laboratory Investigation

Report Sheet

Name__________________________

Science I Hour ________

Date __________________________

THE MEASUREMENT OF MECHANICAL ENERGY

EXPERIMENTAL RESULTS:

I. 1. Weight of cart A _____ g.

2. EF required to move cart A Horizontally _____ g.

3. Work done in moving cart 100 cms. _____

4. a. Weight of cart A + metal weights _____ g.

b. EF required to move cart + weight added _____ g.

5. Work done in moving cart + weights 100 centimeters _____

II. length of board _____ cm.

height of the incline _____ cm.

weight of cart A _____ g.

1. EF required to move cart A along incline _____ g.

2. Work done in moving cart 100 cm. up incline_____

3. Height above table top after traveling 100 centimeters along the incline _____ cm.

4. **Work that would be required to lift the cart from the table top to the same height as attained by pulling it 100 cm up the incline.** _______

QUESTIONS:

1. How much energy would have to be expended to move the cart "A" a distance of 100 centimeters along the horizontal surface of the board?

2. Why was the Effort Force required to move the cart up the incline, with constant speed, greater than the EF required to pull the cart along the surface of the board in Part I?

3. With reference to the table top:

_____ a. How much potential energy was gained by the cart after it had been moved 100 centimeters along the horizontal surface of the board in Part I?

_____ b. How much potential energy was gained by the cart after it had been moved 100 centimeters along the vertical plane in Part II?

______ c. Is the potential energy gained by the cart in Part II greater, less or the same as the mechanical energy used to slide the cart up the incline 100 centimeters.

4. If energy cannot be destroyed or lost, what happened to the mechanical energy which was used to move the cart 100 centimeters horizontally along the board in Part I?

5. Suppose that cart A was to be moved the incline a distance of 100 centimeters upward along the incline in one-half the time that it took to move it the same distance in Part II of the experiment.

______ a. Would the work done in moving the cart up the incline in one-half the time be greater, less, or the same as the work done in moving it with constant speed?

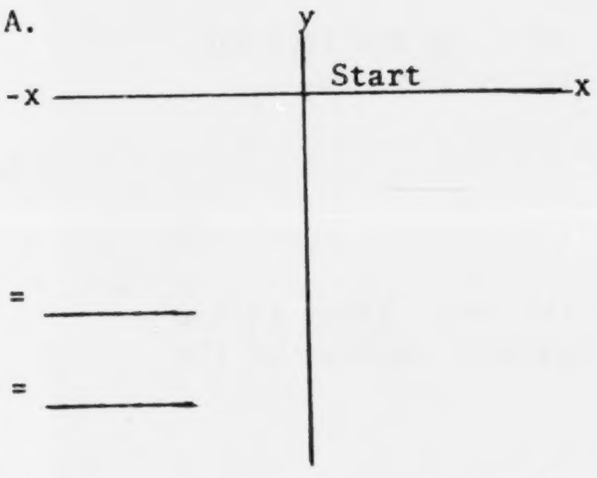
______ b. Would it take more or less energy to move the cart 100 centimeters along the incline in one-half the time?

______ c. Would the potential energy gained by the cart after moving 100 centimeters along the incline, at constant speed, be greater, less, or the same as the potential energy gained after moving 100 centimeters along the incline in one-half the time?

______ d. Is the energy expended in moving a body always equal to the work done on the body?

______ e. Is the potential energy gained by a body always equal to the work done in moving the body?

III A.



F_1 = ________

F_n = ________

SCALE: ________

III B. The magnitude and direction of the RF acting upon the cart parallel to the incline

= ____________

FUNDAMENTAL ENERGY FORMS

Resource Material:

HEAT AND TEMPERATURE

Required Reading:	Energy, Life Science Library, pages 29-36. (Tape - same title)
Recommended Reading:	Energy, Life Science Library, pages 36-45.

QUESTIONS FOR CONSIDERATION:

1. In what century was an adequate device for measuring temperature made?

2. Who first attempted to measure temperature?

3. What did the early thermometers of Galileo and others lack for becoming acceptable measuring devices of temperature?

4. How did Fahrenheit solve the problem of making an accurate thermometer?

5. What are the three temperature scales in use today?

6. Why is it difficult to distinquish between heat and temperature?

7. Who first noted the distinction between heat and temperature?

8. Why does the temperature of water remain at 100°C (212°F) and not increase when heat is added to change the water to steam?

9. a. What theory in the later part of the 18th Century was used to explain heat energy?

   b. What man provided the beginning of the downfall to this false theory of heat?

HEAT ENERGY AND TEMPERATURE

When we measure the temperature of an object we are actually measuring, indirectly, the average speed with which the particles that compose the substance are moving. The liquid in a thermometer "rises" because it expands as its molecules began to move faster in response to the absorption of heat energy. The liquid inside the thermometer expands because the heat energy absorbed by the glass is transferred to the liquid inside.

We use the word "temperature" to describe this physical change which occurs whenever matter gains or loses heat energy.

The kinetic theory of matter suggests that the particle motion of all matter is due to heat energy and that increasing or decreasing the amount of heat energy that a body contains causes a corresponding increase or decrease in its particle motion and its temperature.

When a body loses heat energy its temperature decreases. If a body gains heat energy its temperature increases. It is very important to note, however, that temperature changes do not tell us how much heat energy is gained or lost. A change in temperature occurs whenever heat energy is gained or lost, but the temperature change is not a measure of the amount of heat energy involved in that physical cahnge.

Suppose that we fill a bath tub with very hot water and then dip one cupful of this hot water out of the tub and set it aside. We measure the temperature of the water in the tub and the cup and find that, in each, the thermometer reads 134 degrees Fahrenheit. Since the temperature of the water in the tub and the cup is much higher than that of the surrounding objects, including the air, the water begins to lose heat energy. The cooler matter surrounding the water gains heat energy. Furthermore the heat energy lost by the hot water is exactly equal to the heat gained by the surroundings. During this process, the temperature of the water decreases and the temperature of the surrounding objects increases. After a short time the average rate of motion of all the water molecules in the cup has decreased to the point where the thermometer registers 124 degrees Fahrenheit. During this time each water molecule in the cup has lost a specific amount of heat energy. The amount of heat energy lost by each molecule in the cup is the same as that lost by every other molecule in the cup. It takes a much longer period of time for the water in the bath tub to cool down to the same temperature because it contains many, many, more water molecules. Each molecule in the tub must give up the same amount of heat energy before the average rate of the motion of all the water molecules becomes equivalent to a water temperature of 124 degrees Fahrenheit. The heat loss per molecule in the tub is exactly the same as the heat loss per molecule in the cup when both have cooled to the same temperature.

If the tub contains 1000 cupfuls of water the heat lost by the water in the tub would be 1000 times more than the heat lost by the water in the cup even though both experience the same temperature change. Thus we see that the heat energy lost or gained by a body depends not only on its temperature change but also upon how many molecules experience this temperature change.

FUNDAMENTAL ENERGY FORMS

I. Mechanical

  A. Measurement

  B. Units

II. Heat

  A. Difference Between Heat Energy and Temperature

    1. Temperature and Kinetic Molecular Theory

      a. Measuring Devices

        (1)

        (2)

        (3)

      b. Common Temperature Scales

        (1)

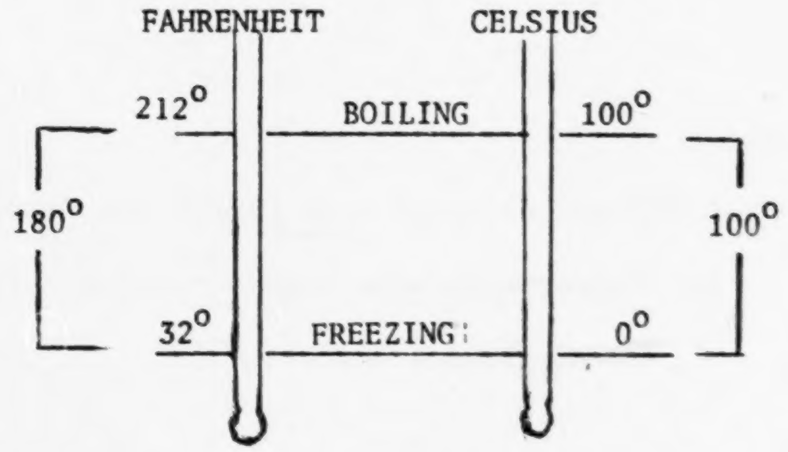
        (2)

        (3)

c. Conversion Between Common Temperature Scales

(1) Fahrenheit to Celsius

(2) Celsius to Fahrenheit


FAHRENHEIT
CELSIUS
212°
BOILING
100°
180°
100°
32°
FREEZING
0°

(3) Celsius and Fahrenheit to Kelvin

Problem Assignment

Name ______________________

Science IA Hour ______ 41

Date Due ______________________

TEMPERATURE CONVERSIONS

1. Convert the body temperature, 98.6 degrees F., to degrees Celsius.

2. Liquid nitrogen boils at a -196 degrees C. Convert this temperature to degrees Fahrenheit.

3. Convert 14 degrees F. to its equivalent temperature in degrees Celsius.

4. Convert -10 degrees Celsius to degrees Kelvin.

5. During the course of a 12 hour period the air temperature ranged from a low of 46 degrees F. to a high of 82 degrees F. Calculate the temperature rise in degrees Celsius.

6. How many degrees Celsius would be equal to 84 degrees Fahrenheit?

7. Convert 19 degrees Fahrenheit to its equivalent temperature on the Kelvin scale.

8. The temperature at the surface of the sun may reach 1×10^4 degrees F. Express this temperature in degrees C.

9. As water is cooled it continues to contract until it reaches a temperature of 4 degrees Celsius. When water is cooled below this temperature it begins to expand. Thus, ice at 0 deg. C., is less dense than water and the ice floats. At what temperature, in degrees F., does water have its greatest density?

10. Calculate the temperature at which the Celsius and Fahrenheit temperature scales are numerically equal.

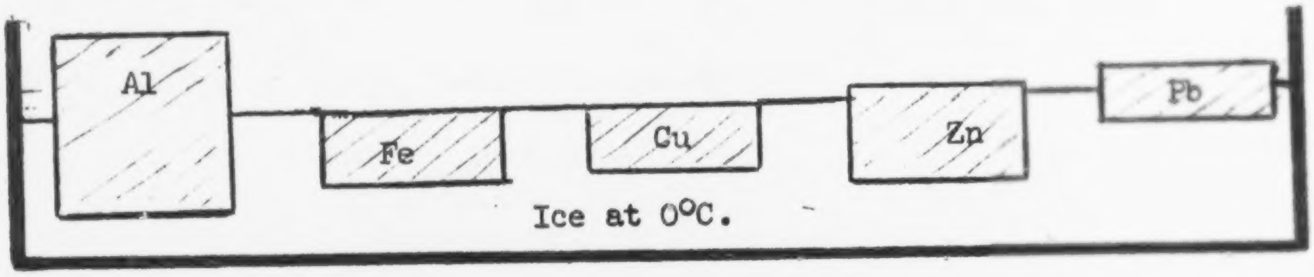
MEASUREMENT OF HEAT ENERGY

Frequently we find it becomes necessary to know how much heat energy a body loses or gains or the amount of heat energy a body may contain at a given temperature. In order to make such measurements possible, scientists have selected a unit for measuring heat energy which takes into account the rate at which particles move (the temperature), the number of particles moving, represented by the weight of the material, and the heat properties of the material represented by specific heat.

The name given to this unit is CALORIE, which means "heat". Water was chosen as the standard for this unit. The calorie was defined as the amount of heat needed to raise the temperature of one gram of water one degree Centigrade.

Our English unit for heat energy is called the BRITISH THERMAL UNIT, or the BTU. It represents the amount of heat energy needed to raise the temperature of one pound of water one degree Fahrenheit.

Water was selected as the reference standard for specific heat and the specific heats of all materials are compared to water. The units then were defined so the standard, water, would require one calorie of heat to raise one gram of water one degree Centigrade or one BTU of heat to raise one pound of water one degree Fahrenheit. Notice that the numerical value for the specific heat of water is one in both the FPS and the CGS systems. If 100 grams of water at twenty degrees Centigrade is heated to thirty degrees Centigrade, then the water gains 1000 calories of heat energy.



Other substances have different heat capacities from water and from each other. The diagram represents block of different metals each weighing 100 grams. Each was heated to a temperature of 100 degrees Centigrade and then set on the surface of the ice after a certain length of time each block has "melted its way" to a different depth in the ice. The aluminum has melted more than twice as much ice as the block of lead in spite of the fact that both blocks had the same weight and were at the same initial temperature. Apparently the heat capacity (specific heat) of aluminum is more than twice as great as that of lead. The block of aluminum must have lost more than twice as many calories as the block of lead. The number of calories that any material looses or gains per gram when its temperature is altered one degree centigrade is called its SPECIFIC HEAT. With very few exceptions, the specific heat of matter is less than the specific heat of water.

The amount of heat energy a body has cannot be measured directly, but only in terms of a temperature change. That is, given a piece of metal, weight 20 grams at a temperature of 50°C., with a specific heat of .11 cal/g°C, we cannot know or determine how much heat energy it contains. But if we place this piece of metal in ice water of known weight and temperature and wait for the heat from the metal to transfer to the water and have both metal and water reach an equilibrium temperature (temperature between the warm metal and the cold water) we can determine how much heat energy was transferred from the metal to the water. This heat energy is the energy the metal had in the beginning. Therefore, to measure heat energy, heat must flow or be exchanged from one object to another. This heat transfer is indicated to us by a rise and a corresponding fall in the temperature of the objects. In a system in equilibrium there must be an object or objects which loses heat and an object or objects which gain heat, and the amount of heat lost must equal the amount of heat gained. The measurement of heat energy depends on the number of molecules (weight of an object), the change in speed of those molecules (temperature change), and the type of material the molecules are made of (specific heat).

heat energy = weight of object x temperature change x specific heat

$$Q = W \times \Delta t \times Sp.H.$$

"Δ" is the Greek letter "delta" which means "change in".

If the law of heat exchange is used to determine a certain quantity in the above equation then:

heat lost from one object = heat gained by second object

$$Q_1 = Q_2 \quad \text{or}$$

$$W_1 \times \Delta t_1 \times Sp.H._1 = W_2 \times \Delta t_2 \times Sp.H._2$$

If object 2 is water of known specific heat, other objects' specific heats can be determined by using the above equation.

The device used in heat exchanges to measure heat energy is the calorimeter. It consists of a large aluminum outer can and an inner calorimeter cup in which a stirrer and thermometer are inserted. The stirrer is used to uniformly distribute the heat in the system and the thermometer of course indicates the temperature changes in the system.

B. Heat - The Total Kinetic Energy Possessed by a Body Due to the Motion of Its Particles

1. Factors That Affect the Quantity of Heat Energy Possessed by Matter

a. Number of Molecules Moving (Weight)

b. Average Rate of Molecular Motion (Temperature)

c. Thermal Properties of the Material (Specific Heat)

2. Technique for Measuring Heat Energy Lost or Gained

a. Conditions Under Which Heat Energy Can be Transferred

b. Measuring Devices

c. Quantitative Representation of Heat Energy Lost or Gained

$$Q = F_w \cdot \Delta t \cdot Sp.Ht.$$

d. Units of Heat Energy

(1) calorie

(2) BTU

C. Conservation of Energy In Heat Transfer

Heat Lost = Heat Gained

SPECIFIC HEAT AND THE MEASUREMENT OF HEAT ENERGY

Introduction: Whenever a temperature difference exists between materials within a closed system heat energy will be exchanged. The warmer substances will loose heat and the colder substances will gain heat. This exchange of energy will continue until all matter within the system is at the same temperature.

Problem: Design an experimental procedure which will provide the information needed to determine the specific heat of the substance provided.

Questions:

1. Is our solar system in thermal equilibrium?
2. What term is used to describe the present trend in distribution of energy within the universe?
3. Which of the physical quantities associated with the determination of the specific heat of your sample was most critical as far as accuracy of results is concerned? Why?
4. How many lbs of lead, Sp.H. = 0.03, would have to be added to 10 lbs of water in order to increase the temperature of the water from 70°F to 80°F. Assume the initial temperature of the lead to be 200°F.

Problem Exercise

Name ____________________

Science I. Hour _____

Date ____________________

CALORIMETRY

(Heat Lost = Heat Gained)

1. Calculate the number of calories of heat energy required to raise the temperature of 100 g. of lead from 24° C to its melting temperature which is 327° C. The specific heat of lead is 0.03.

2. How many Btu's of heat energy would be required to raise the temperature of 2 quarts of water from room temperature, 76° F to the boiling point at 212° F? One quart of water weighs 2 pounds.

3. In a certain calorimetry measurement, 100 g. of water gained 1000 calories of heat energy. How many degrees Celsius did the temperature of the water change?

4. A calorimeter containing 200 g. of water at 20° C absorbed 4000 calories of heat energy. Calculate the final temperature of the water.

5. A slice of white bread was burned in a calorimeter. The heat evolved in the process raised the temperature of 400 g. of water from 25° C to 40° C. Calculate the number of calories contained in the bread. How many Calories would this equal?

6. A certain metal weighing 50 G. was heated in a boiling water bath until its temperature was equal to 100° C, the same as the boiling water. The hot metal was then quickly transferred to a calorimeter containing 250 g. of water at 20° C. At equilibrium the temperature of the "system" (water plus metal) was 24° C. Calculate the specific heat of the metal.

7. An aluminum pan was used to raise the temperature of 4 quarts of water from 70° F to 180° F. If the pan weighed 2 pounds, how many Btu's were absorbed by the pan. The specific heat of aluminum is 0.2.

8. How much more heat did the water described is problem # 7 absorb than the pan?

The Mechanical Equivalent of Heat Energy

INTRODUCTION:

The expenditure of energy in any form may result in work (F x d; F//d) being done. Frequently it is more convenient to measure and represent the work done in equivalent units. The measurement of heat energy and electrical energy are examples where this is true.

Forces resulting from the release of energy may cause increased particle activity within a body. This type of particle motion is called "thermal agitation". Increased thermal agitation in matter produces a physical change which we recognize as an increase in temperature.

The quantity of energy expended in producing an increase in particle activity may be measured in terms of the number of particles moved (represented by weight) times the change in the rate of particle SPECIFIC HEAT of the material.

The Specific Heat of any material is a number which tells how much heat energy is needed to raise the temperature of 1 gram of the material 1 degree Celsius + or - ; the amount of heat needed to raise the temperature of 1 lb of the material 1 degree Fahrenheit. Scientists have selected water as a standard of reference for specific heats and have assigned to it the numerical calue 1. Thus the specific heats of all materials are compared to that of water which is 1.0.

The heat energy which is lost or gained, as a result of changes in the rate of particle activity = wt x temp change x SpHt.

In the English (British) system, where wt is expressed in lbs and temperatures in degrees Fahrenheit;

wt x temp change x SpHt = Heat lost or gained
lbs x deg. F. x SpHt = British Thermal Units (Btu's)

In the metric system;

g x deg C x SpHt = calories

Thus we find that 1 Btu is the quantity of heat energy needed to raise the temperature of 1 lb of water 1 deg Fahrenheit. 1 calorie is the quantity of heat needed to raise the temperature of 1 g of water 1 deg Celsius.

This relationship requires that the numbers used to represent the specific heats of materials must have units.

The SpHt of water = $\frac{1\ \text{Btu}}{\text{lb}\ \text{F}^{\circ}}$ or $\frac{1\ \text{calorie}}{\text{g}\ \overset{\circ}{\text{C}}}$

Substituting these values for SpHt into the equation, and canceling, we have:

Quantity of Heat lost or gained = wt x temp change x SpHt

$$\text{Btu's} = \frac{\cancel{\text{lbs}} \cdot \cancel{\text{F}^{\circ}} \cdot 1\ \text{Btu}}{\cancel{\text{lb}}\ \cancel{\text{F}^{\circ}}}$$

Laboratory Problem 51

THE MECHANICAL EQUIVALENT OF HEAT

PROBLEM:

Determine the numerical relationship for energy expended in mechanical (work) units and its equivalent value in heat units. On the basis of experimental evidence determine how many g - cm = 1 cal.

THEORY:

The law of conservation of matter and energy states that the energy gained by one body must be equal to the energy which is lost by some other body.

The amount of work that is done on a body, in raising it from one height to another, will be equal to the amount of work that would be done by the body if it were to fall back down to the original level.

Assume that this law is applied to a system made up of a quantity of lead shot enclosed in a long cardboard tube. When the tube is held in a vertical position and then inverted a specific amount of work is done on the shot as it is raised to the top of the tube. The lead shot has gained energy. As soon as the shot reaches the top of the tube it immediately falls to the bottom. As the shot strikes the bottom it must return the energy it had gained. If the force of the shot, exerted against the bottom of the tube, does not move the bottom cover through any distance the energy possessed by the shot is not returned as work, F · D; F//d. If this is actually the case the collisions between the "immovable" bottom cover and the shot forces the atoms within the lead shot to move at a faster rate. This increase in particle motion increases the temperature of the shot. The net result is that the mechanical energy gained by the lead shot, while being moved upward, is returned as an equivalent amount of heat energy when the lead strikes the bottom of the tube.

The amount of mechanical energy gained by the lead may be determined by measuring the work done on it. The equivalent amount of energy, returned as heat, may be measured by pouring the heated lead into a known weight of water and observing the change in temperature. When the temperature of the lead and the temperature of the water are equal the system is said to be in EQUILIBRIUM. At equilibrium the heat energy lost by the lead, in cooling, must be equal to the heat energy gained by the water as its temperature increased.

Quantity of Heat Lost or Gained = wt. x temp. change x SpHt

$$\text{Calories} = \frac{\cancel{g}\quad \cancel{C}^{\circ}\quad 1\ \text{calorie}}{\cancel{g}\ \cancel{C}^{\circ}}$$

The Btu and the calorie are units used to measure energy released in the form of heat. They are "indirect" measurements of the energy since they describe the work which is done in terms of the temperature rise in a given weight of a material.

In order to determine quantities of heat energy gained or lost by materials it is necessary to measure weights and temperatures. In order to determine mechanical energy done on or by a physical body, we must measure weight and distance.

EXPERIMENTAL DATA:

Weight of Lead Shot ________

Length of Tube ________

No. of Inversions ________

Calorimeter System

PARTS	WEIGHT	Δt	SP.HT.

ANALYSIS OF DATA:

Mechanical Energy Lost = Heat Energy Gained

(Work Done on Lead Shot) = Heat Energy Gained by the Calorimetric System

F·D (F//d) = wt. x Δt x Sp.H. (of calorimeter system)

QUESTIONS:

1. Define: (a) BTU -

   (b) calorie -

2. Convert one BTU to its equivalent value in calories. Show substitution of units and number values in your equation.

3. Explain what is meant by the term "equilibrium" as it applies to systems which experience energy exchanges.

4. Which measurement in this experiment do you believe to be most critical (important) in the determination of the energy equivalent? Why?

D. Mechanical Equivalent of Heat Energy

III. Electrical

A. Conditions Required to Produce Electrical Energy

B. Measurement

C. Units

D. Electrical Equivalent of Heat Energy

IV. Equivalence Between Energy Forms

	UNITS			EQUIVALENT
	F.P.S.	C.G.S.	M.K.S.	
MECHANICAL				
HEAT				
ELECTRICAL				

ENERGY, TIME, AND THE CONCEPT OF POWER

I. Physical Quantities Associated with Power

A.

B.

C.

II. Power, A Scalar Quantity

III. Units and Measuring Techniques

A. English

1. foot lb / sec

2. horsepower

B. Metric

1. watt

2. kilowatt

IV. Equivalence Between Power Units

A.

B.

Science IA
Problem Assignment

Name____________________
Science IA Hour________
Date due__________________

ENERGY, WORK, POWER

Sample Problem: How much horsepower would have to be generated in order to raise the temperature of 120,000 g of H_2O, 50°C. in 30 minutes?

$$P = \frac{w}{t}\ ; \quad w = Q$$

$$= \frac{120{,}000\text{ g.} \times 50^{\circ}\text{C} \times 1}{30\text{ min.}} \times \frac{1\text{ cal}}{1\text{g}^{\circ}\text{C}} \times \frac{1\text{ B.t.u}}{252\text{ cal}} \times \frac{778\text{ Ft.lb.}}{1\text{ B.t.u.}} \times \frac{1\text{ min}}{60\text{ sec}} \times \frac{\text{sec } 1\text{ Hp}}{550\text{ Ft.lb.}}$$

$$= 18.7\text{ HP.}$$

1. A loading crane raised a 2000 lb. crate 40 ft. from a dock to the deck of a ship. How much work was done on the crate?

2. Calculate the number of Btu's required to raise the temperature of 140 g of water from 0 deg. C. to its boiling point.

3. A force of 160 lbs was required to push a piano, weighing 2440 lbs., along the floor with uniform speed. Calculate the work done in moving the piano along the floor, 18 ft., to the opposite end of the room.

4. The heat energy released when a slice of white bread was completely burned was sufficient to raise the temperature of 200 g of water from 23 degrees C. to 78 degrees F. How many calories of heat energy were obtained from the bread in the process?

5. The end of a copper rod was flattened by rapid pounding with a hammer and then quickly thrust into a beaker of water. The beaker contained 200 g of water at 24 degrees Celsius. The temperature of the water increased to 26 degrees C. Calculate the number of ft. lbs. of work done in flattening the rod. You may assume that the mechanical energy is equal to the heat energy gained by the water.

6. An electric water heater, rated at 1600 watts, was operated for 2 hours. Calculate:

   (a) the electrical energy used

   (b) the cost of the operation at the rate of 4¢/Kw.Hr.

7. The water heater described above contains 80 gallons of water. At the beginning of the two hour heating period its temperature was 80 degrees F. Calculate the final temperature of the water after the two hour period. *You may assume that 1 qt. of water weighs 2 lbs.

8. A block of iron weighing 1000 g. was raised to a height of 100 meters and then dropped into a vessel containing 4 liters of water at 24 degrees C. If all of the kinetic energy possessed by the iron at the moment it struck the surface of the water was converted into heat energy in the water, what was the final temperature of the water?

Resource Material

ENERGY RESOURCES AND THEIR UTILIZATION

Required Reading: Energy, Life Science Library, pages 9-12, (Tape Same Title)

Next Hundred Years, Brown, 600 B87 (L), pages 10-16, 95-102, 103-113

Recommended Reading: Energy, Schurr, S. A., Sept. 1963, Vol. 209, #3, page 110

Foreseeable Future, Thonson, 600 T48 (L), pages 15-33

Nine Roads To Tomorrow, Halary, 608 H15n (L), pages 94-108

Wonderful World of Energy, Hogben, 621 H71 (L), pages 66-69

Push and Pull, Blackwood, 531 B63 (L), pages 17-22, 138-160 161-172

QUESTIONS FOR CONSIDERATION:

1. Consider the statement. "Large differences in income are associated with large differences in energy intake, and we may take it for granted that no country at this stage of history can enjoy a high per capita income without becoming an extensive consumer of energy."
   (a) Would this statement have been true 200 years ago? 1500 years ago? 2000 years ago?
   (b) Is there any relationship between extensive energy consumption and military might? Consider China and Russia in this regard? England and the U.S.? What does the future hold for these countries?
2. What problems are involved in estimating fuel resources in the world? In estimating energy (power) requirements for the future?
3. How does our central theme Matter + Energy + Time = Change--relate to the subject of energy resources? (Consider past, present, and future conditions) For instance North America is tremendously rich in coal and oil resources, what does this suggest as to the past history of this region, what effect is it having today and what effect will it have on the future of this region?
4. Why is it difficult to develop a concept of energy?
5. When energy is put to work in its various forms, is any lost?

MAN'S EARLY ATTEMPTS TO UTILIZE AND UNDERSTAND ENERGY

I. Practical Attempts at Harnessing Energy

  A. Prehistoric

  B. Ancient

  C. Medieval

  D. Modern

II. Man's Ideas about Energy

  A. Prehistoric

  B. Ancient

    1. Thales

    2. Heraclitus

    3. Empedocles

    4. Aristotle

C. Medieval

1. Galileo

2. Leibniz

3. L. N. Carnot

4. Development of Caloric Theory

5. Count Rumford

6. *Sir Humphry Davy*

7. Thomas Young

Resource Materials

ENERGY RESOURCES AND THEIR UTILIZATION

Required Reading:	"Energy", Sam H. Schurr, Scientific American Reprinted with permission.
Recommended Reading:	"Energy for Man, From Windmills to Nuclear Power", Hans Thirring "Energy and Economic Growth", Haig Babian, American Petroleum Institute "Fossil Fuels in the Future", U.S. Atomic Energy Commission
Audio Tape:	"Our Energy Resources", taken from "The Next Hundred Years", Harrison Brown
A.V. Program:	"Energy"

INTRODUCTION:

Modern man has made himself largely by burning fuel. There is an obvious connection between the economic development of a society and its use of energy from mineral resources.

Based on present trends, it is estimated that the world consumption of mineral fuels between now and the end of the century will equal about three times the amount consumed in all previous history. Since mineral fuels (fossil fuels) are expendable resources, unequally distributed around the world, it is easy to see why there is a need for concern about the ability of the world's resources to meet estimated future consumption.

The development and utilization of energy resources constitutes one of the major problems that must be recognized and solved if society is to continue or improve its economic development in the future. It is the responsibility of every citizen to become familiar with the complexities and urgency of this problem and with the prospects for its solution.

Since the beginnings of the Industrial Revolution, world production of coal has risen until it is now nearly 2 billion metric tons per year. Well into the 20th century coal was the chief source of energy.

In 1859 Col. Edwin L. Drake drilled the first commercially successful oil well at Titusville, Pa. Two thousand barrels of oil were produced that year. By 1900 crude oil production had increased to 64 million barrels annually and in 1963 the United States production of crude oil was about 44 times as great as that of 1900; 2.8 billion barrels. World production of crude oil now exceeds 10 billion barrels annually.

Today petroleum is our principle energy resource. Oil and natural gas together provide almost three quarters of the total U.S. energy supply.

The amount of energy derived from coal has decreased from 15,504 trillion BTU's in 1920 to 11,109 trillion in 1963. During the same period energy derived from oil increased from about 2,634 trillion to 20,262 trillion BTU's per year. Corresponding figures for natural gas were 869 trillion and 16,343 trillion BTU's. In other words, while total energy consumption in the United States has more than doubled since 1920, energy from oil has increased about eight times and that from natural gas about 19 times.

These three sources, coal, petroleum, and natural gas are the major energy resources. Although water power, hydroelectric generation of electrical energy, is very important in certain regions, it is relatively negligible when we consider the energy requirements of the world as a whole.

In 1960 the world's total energy consumption was calculated to be the equivalent of 4,235 million metric tons of hard coal. This amounts to about 1.4 tons of coal per person. This per capita figure for a world average is very misleading since the various countries expend energy at different rates. The U.S. for example, with only 6% of the world's population consumed more than 33% of the total annual world production of energy. India, at the other extreme, with almost 15% of the world population used only about 1.5% of the world's commercial energy.

If all the people of the world were to expend energy at the per capita rate at which we expend it in the United States, the total rate of energy expenditure would increase approximately 6 times; equivalent to 25 billion tons of coal per year. In view of the fact that energy cost per unit of industrial output are bound to climb considerably in the future, and that the population of the world is destined to become considerably greater than the 3 billion of 1965 total, world demands for energy could well exceed the equivalent of 100 billion tons annually.

How much energy is available in the world? How long could we continue to expend energy at such a rate? What are the prospects of developing other energy resources to supplement or replace the "big three" - coal, oil, and natural gas? Do energy resources constitute a serious threat to the survial of man on this planet? These are some of the questions we will relate to in this section of our study.

QUESTIONS FOR CONSIDERATION:

1. What is the present per capita energy utilization in the United States? How does this compare to the world average? How do you account for the large discrepency between these two averages?

2. What is meant by "hard coal equivalent"? How many BTU's are equal to one pound of hard coal equivalent? Give energy values for the following in terms of hard coal equivalents (hce). How much of each is needed to equal one hce? natural gas, electricity

3. Identify, in order of importance, the primary fuel resources which provide the energy requirements of the United States.

4. Discuss rates of utilization and estimated reserves for the following (United States only):

   a. coal b. natural gas c. petroleum (crude oil)

5. What percentage of the total energy utilized in the United States in 1964 was electrical energy?

   a. What percentage of this total was produced by utilities which burn fossil fuels as the original energy source? How efficiently can the energy of coal be converted into electrical energy?

   b. What percentage of the total electrical energy utilized is produced by (water power) hydroelectric utilities? How efficient is this conversion?

   c. What percentage of the total electrical energy is produced by nuclear reactor utilities?

6. What are the four major consuming sectors in our energy economy? What percentage of the total energy utilized in the United States does each of these sectors account for?

7. Discuss the percent breakdown of petroleum products used in transportation.

8. Discuss the difference between renewable and nonrenewable energy resources. What percentage of the total energy utilized annually in the United States is derived from renewable energy resources?

9. Based on our present rate and preference in the utilization of fossil fuels and anticipated reserves, discuss possible depletion dates for the following:

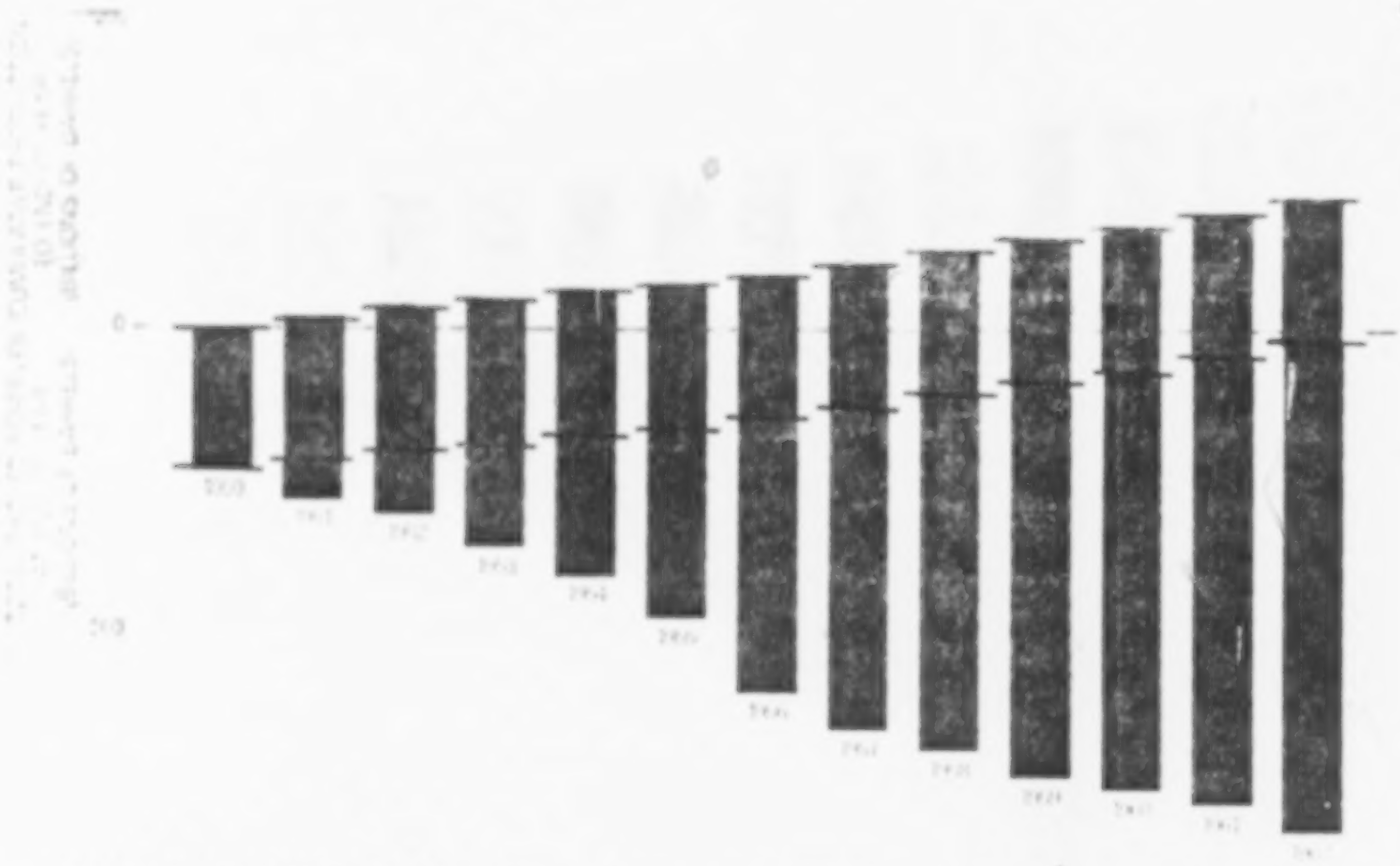
   a. coal
   b. petroleum (crude oil)
   c. natural gas

10. If the per capita energy utilization for the world were the same as it is in the U.S. and, taking into account increases in world production, how long would our fossil fuel resources last?

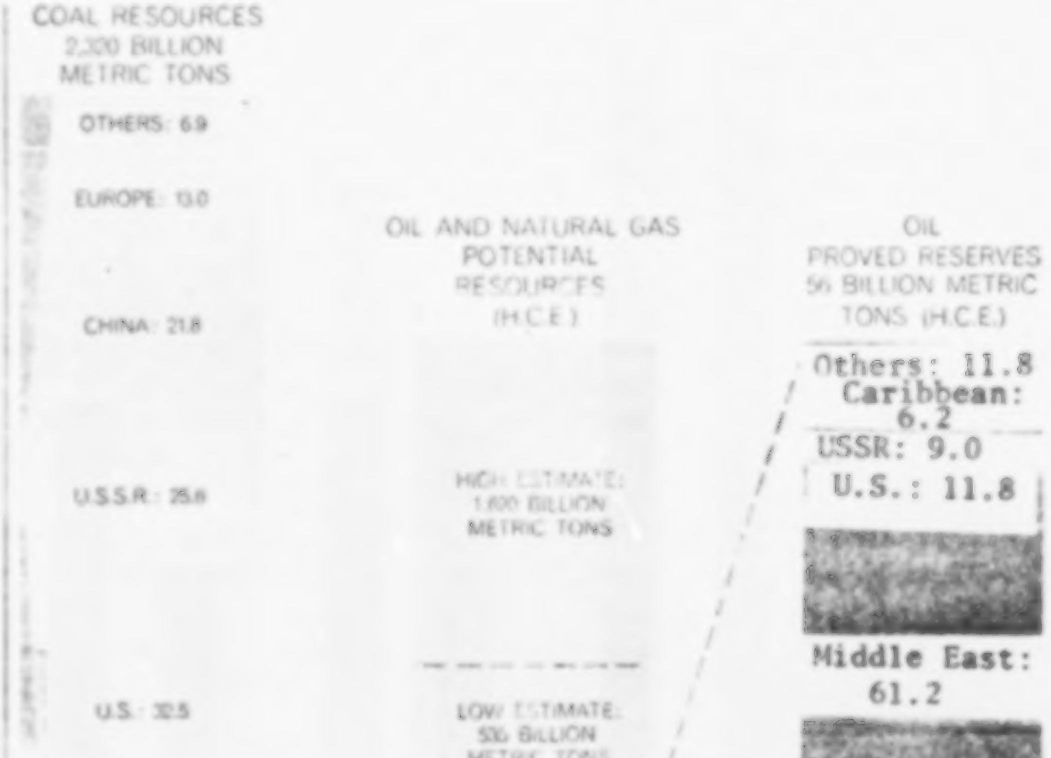
1960 figures

REGION	ENERGY CONSUMPTION (MILLIONS OF METRIC TONS H.C.E.)	PER CENT OF WORLD TOTAL	POPULATION (MILLIONS)	PER CENT OF WORLD TOTAL	PER CAPITA ENERGY CONSUMPTION (KILOGRAMS H.C.E.)
WORLD TOTAL	4,235	100.0	3,017	100.0	1,404
NORTH AMERICA, WESTERN EUROPE AND OCEANIA	**2,432**	**57.5**	**540**	**17.9**	**4,504**
NORTH AMERICA	1,549.3	36.6	199	6.6	7,785
U.S.	1,447.8	34.2	181	6.0	7,999
CANADA	101.5	2.4	18	0.6	5,639
WESTERN EUROPE	837.3	19.8	326	10.8	2,568
"COMMON MARKET"	440.9	10.4	169	5.6	2,609
UNITED KINGDOM	259.0	6.1	53	1.8	4,887
OTHER	137.4	3.3	104	3.4	1,321
OCEANIA (AUSTRALIA AND NEW ZEALAND)	45.6	1.1	15	0.5	3,040
U.S.S.R. AND EASTERN EUROPE	**907**	**21.4**	**313**	**10.4**	**2,899**
U.S.S.R.	610.6	14.4	214	7.1	2,853
EASTERN EUROPE	296.9	7.0	99	3.3	2,999
LATIN AMERICA, MIDDLE EAST, AFRICA AND ASIA	**896**	**21.1**	**2,164**	**71.7**	**414**
CARIBBEAN AMERICA	78.0	1.8	88	2.9	886
OTHER LATIN AMERICA	61.3	1.4	122	4.0	502
MIDDLE EAST	36.9	0.9	138	4.6	267
AFRICA	59.3	1.4	190	6.3	312
ASIA	660.3	15.6	1,626	53.9	406
INDIA	60.7	1.4	433	14.3	140
JAPAN	108.5	2.6	93	3.1	1,167
COMMUNIST ASIA	446.8	10.6	745	24.7	600
OTHER	44.3	1.0	355	11.8	125

WORLD ENERGY CONSUMPTION, population and per capita consumption are shown for 1960. Only commercial energy sources are included: the various kinds of mineral fuel and hydroelectric power are converted, according to energy content, to their hard-coal equivalents (h.c.e.). Oceania, grouped with North America and western Europe, is made up chiefly of Australia and New Zealand. Caribbean America includes Colombia and Venezuela plus all of Central America and the Caribbean islands. The data used in this and subsequent charts in this article (unless otherwise noted) were prepared by Resources for the Future, Inc. from UN statistic-



PROVED WORLD RESERVES OF CRUDE OIL increased enormously in the past decade. The upper segment of the bar in 1950 represents total world crude-oil production between 1859 and 1950. That volume was slightly exceeded by the proved reserves at the end of 1950. Between 1950 and 1962 total crude production almost equaled the reserves of 1950, as indicated by the upward shift of colored segment of bars. Meanwhile reserves more than tripled. Chart is based on one by the British Petroleum Company Limited.



WORLD COAL RESOURCES far exceed estimates of potential oil resources. The coal estimate was compiled by Paul Averitt of the U.S. Geological Survey. The high estimate for oil and natural gas was made by Alfred D. Zapp of the same organization, the low estimate by M. King Hubbert of the Shell Development Company. Data on the proved reserves of oil are from British Petroleum. (The U.S. fraction includes natural-gas liquids.) The bases of the various estimates are explained in the text. In the U.S. alone it is estimated that potential uranium resources are more than 2,000 billion metric tons h.c.e. Between 1960 and 2000 the total world energy consumption may well exceed 400 billion metric tons h.c.e.

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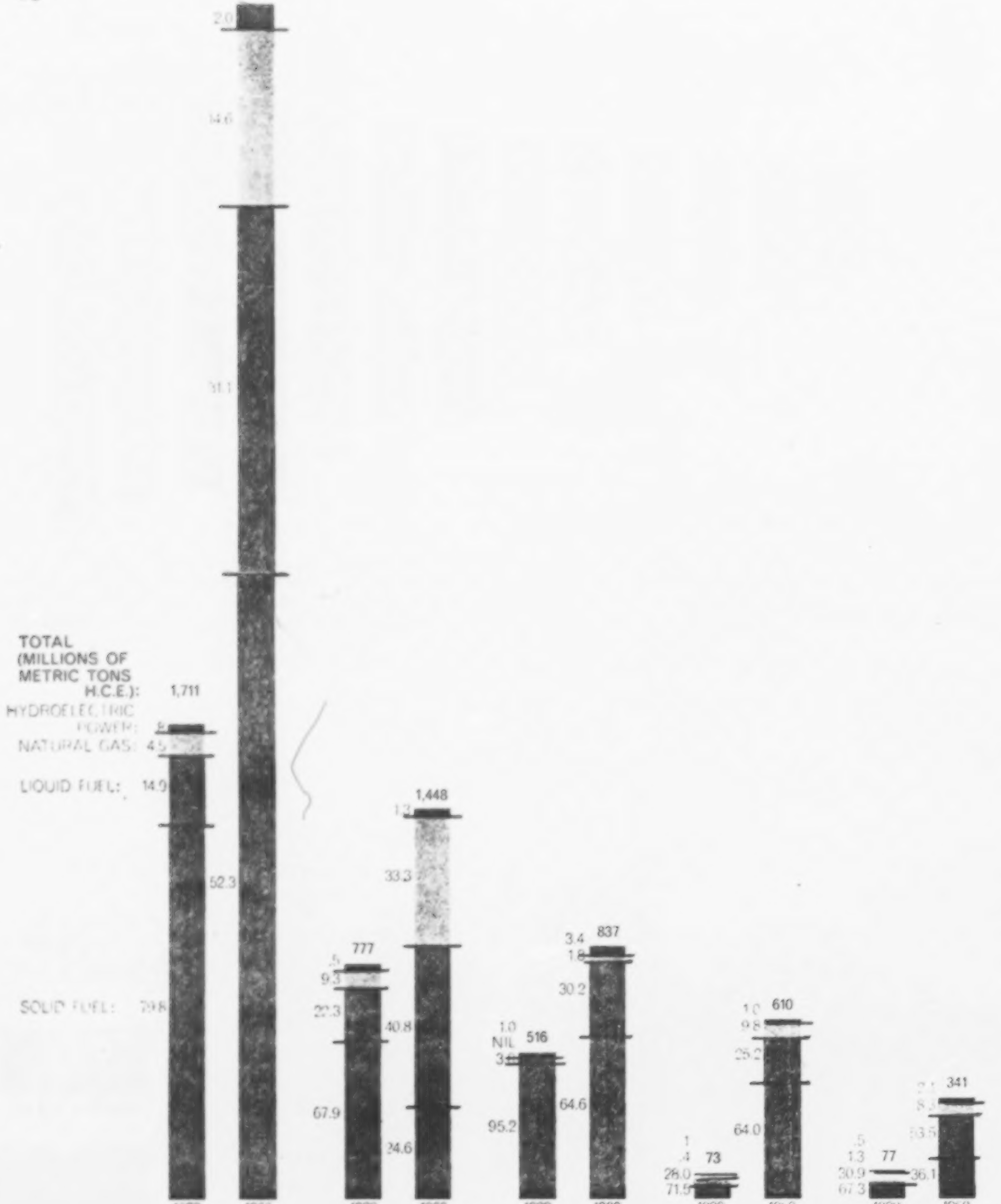


RISE IN ENERGY USE from 1929 to 1960 is plotted for the world as a whole and for selected geographical subdivisions. (Figures for Japan and Communist Asia are omitted from the Asian fraction. The numerals to the left of the bars show per cent composition.) Within this period the total amount of energy supplied by oil and natural gas expanded about 480 per cent, whereas the amount supplied by solid fuels rose only about 60 per cent. The biggest rise in solid-fuel consumption, 650 per cent, took place in the U.S.S.R.

ENERGY RESOURCES AND THEIR UTILIZATION

I. Economic Development and Mineral Resources

A. "Have" and "Have Not" Countries

(1960)	WORLD	USSR	COM. ASIA	AFRICA	INDIA	US
Total Energy Consumption (m tons hce)						
Population (billions) %						
Energy Utilization %						
Per Capita Energy Consumption (Kg hce)						

B. Energy Use and Gross National Product - (GNP)

1. Changes in Energy Utilization 1929-1960

	Total (m tons hce)	SOURCE OF ENERGY (%)			
		solid fuels	liquid	gas	hydroelectric
1929					
1960					

2. Energy Utilization and Gross National Product

	Energy Use (hce/cap)	GNP (dollars/capita)
U.S.		
India		

3. Projected Statistics on Population and Energy Consumption

World	Population	Energy Utilization (hce)
1960		
1980		
2000		

C. The Fossil Fuels

1. COAL
   a. total "proved" reserves ____________________
   b. estimated annual req. (yr. 2000) ____________________
   c. years to depletion ____________________
2. OIL
   a. reserves
      1. total proved ____________________
      2. conservative estimate ____________________
      3. optimistic estimate ____________________
   b. estimated annual req. (yr. 2000) ____________________
   c. years to depletion
      1. minimum ____________________
      2. maximum ____________________
3. NATURAL GAS
   a. reserves
      1. total proved reserves ____________________
      2. conservative estimate ____________________
      3. optimistic estimate ____________________
   b. estimated annual req. (yr. 2000) ____________________
   c. years to depletion
      1. minimum ____________________
      2. maximum ____________________
4. VEGETATIVE

III. Non-Carboniferous Sources (Non-Renewable)

A. Nuclear Fission (slow neutron reactors)

1. estimated resource of U^{235}

a. conservative ____________________

b. optimistic ____________________

2. estimated annual requirement ____________________

3. years to depletion

a. minimum ____________________

b. maximum ____________________

B. Fission "Breeder" Reactors

C. Nuclear Fusion

D. Trends in Development of Nuclear Power Plants

	Number of Plants	Estimated Power Output
1. 1967		
2. 1974		
3. 2000		

IV. Non-Carboniferous Fuels (Renewable)

A. Hydroelectric, conventional

1. present production

2. estimated maximum production

B. Environmental Sources	Current Utilization	Estimated Maximum
1. Hydrolectric - Tidal	____________	____________
2. Wind	____________	____________
3. Terrestrial Heat	____________	____________
4. Atmospheric Electricity	____________	____________
5. Solar	____________	____________
a. thermal		
b. photoelectric		

V. Other Possible Fuel Sources

A. Oil Shale

B. Fuel Cells

Exercise

Name ______________________
Science IA Hour ________
Date ______________________

ENERGY RESOURCES AND THEIR UTILIZATION

On the basis of what you have read and our discussions on this topic summarize, using short statements, the ideas which you consider to be most important.

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

Resource Material

ORDER-DISORDER, AND THE PROCESS OF CHANGE

The ongoing process by which matter within the sun is continuously converted into energy and then radiated outwards, in all directions, into space is one example of increasing entropy in nature. Processes like this which result in energy being scattered is one reason why it is possible for work to be done. For example, we know that gasoline contains a great deal of potential energy concentrated in a small volume. When the gasoline is burned the energy which is released can be made to do work. As a result of the increase in entropy work is done.

Eventually the energy released from the initial volume of gasoline will be uniformly distributed within the boundries of the system. At this point its entropy can no longer increase. This condition is called a state of "maximum entropy."

As the distribution of energy becomes more nearly uniform it becomes more difficult to do work. At maximum entropy no work can be done. If we think of the entire universe as one system we realize that energy is becoming more and more diffuse and that, subsequently, it will become more and more difficult to accomplish the work in the universe associated with life processes.

Whenever energy interacts with matter changes result. For convenience in study and investigation we classify these changes into three categories: (1) physical (2) chemical (3) nuclear. (Work is associated with the process of physical change.)

Prior to entering into a rather extensive study of the nature of these types of change we will take time to establish working definitions for these terms and to discuss the relationship between energy distribution, utilization, and change as a part of the evolutionary processes in the universe.

Required Reading: "Entropy, the Law of the Universe", Science World, Oct. 11, 1961, pages 10-13

Audio Tape Same Title

Recommended Reading: Energy, Life Science Library, 574, Chapter III The Torrid Pace of Moving Molecules, pages 51-69

QUESTIONS FOR CONSIDERATION:

1. Our present answer to the question, "What is heat?" is based on the work of the British physicist James Prescott Joule (1824) who performed experiments to show that heat and work are related. This relationship is the basis of our First Law of Thermodynamics. State this law in your own terms and be prepared to discuss its meaning.

2. The German scientist Rudolf Clausius (1857) made further contributions to our understanding of what heat is. His work is summarized in our "Second Law of Thermodynamics." How is the Second Law of Thermodynamics related to the concept of Entropy?

3. Give an example of some process or system which illustrates increasing entropy.

4. Give an example of some process or system which illustrates decreasing entropy.

5. Is it possible for man to decrease entropy in the solar system?

   Be prepared to discuss your thinking on this question.

6. Entropy has been defined, can it be measured?

   If so, how?

7. What is meant by the "Heat Death" of the Universe?

8. The process by which energy is converted from kinetic to potential or from potential to kinetic always involve interaction with matter. These interactions produce change! Scientists have observed that these changes are of three general types. Identify each of these types of change and give an example to illustrate each. For each example determine whether the energy evolved experiences an increase or decrease in entropy.

ORDER-DISORDER, AND THE PROCESS OF CHANGE

I. The Laws of Thermodynamics

II. Increasing Entropy, Part of the Natural Evolutionary Process

III. Change, the Product of Interaction between Matter and Energy with Time

IV. Classification of Types of Change that Occur in the Universe

A. Physical Change

B. Chemical Change

C. Nuclear Change

V. Change and Entropy in Living and Non-Living Systems

Exercise

Summation of Ideas

Name ______________________

Science IA Hour _______

Date Due ______________________

THE ROLE OF ENERGY AND TIME IN THE PROCESS OF CHANGE

On the basis of our study relating to the role of energy and time in the process of change identify the "big ideas" which are fundamental to your concept of energy and its role in the process of change. Express each idea in a clear concise statement.

1. ______________________

2. ______________________

3. ______________________

4. ______________________

5. ______________________

6. ______________________

7. ____

8. ____

9. ____

10. ____

11. ____

12. ____

Review Questions

Name ______________________

Science IA Hour ____

Date ______________________

THE ROLE OF ENERGY AND TIME IN THE PROCESS OF CHANGE

1. Identify two general properties of radiant energy. That is, identify two facts which are true for all kinds of radiant energy.

2. In what way does mechanical energy differ from radiant energy?

3. Where does energy come from?

4. Does all matter contain energy? Explain.

5. All energy that exists is either in a kinetic state or a potential state. What is the difference between kinetic and potential energy?

6. When one measures the temperature of a body, what is actually being measured?

7. What factors determine how much heat energy a particular piece of matter contains?

8. A calorimeter cup weighs 30 grams and has a specific heat value of .2. The starting temperature of the 150 grams of water in the cup is 15°C. A 60 gram piece of metal at temperature 100°C is added to the water. The final temperature of both is 66°F.
   a. convert 66°F to °C.

   b. calculate the specific heat of the metal.

9. A bullet weighing 5 grams was shot into a tank containing 10 gallons of water. The initial temperature of the water was 25°C. The velocity of the bullet was reduced to zero and the heat absorbed by the water caused its temperature to rise to 25.5°C. Calculate the work done by the bullet. (One gallon of water weighs 8 lbs.)

10. Discuss the concept of entropy and its relationship to the second law of thermodynamics.

11. Who invented the term entropy?

12. List one way in which man harnessed energy in the following ages of time.

    Modern (18th century - present)

    Ancient (15th century A.D. - 10th century B.C.)

    Prehistoric (cavemen)

13. Name the two fundamental forces in Thales' universe. Why would he consider them the fundamental forces?

14. Who was Archimedes?

15. Which Greek philosopher considered that "Love" and "Hate" were the two fundamental physical forces in the universe and that the force of "Hate" was increasing?

    What present day theory (word) describes a similar situation?

16. What 18th century theory was an attempt to describe the energy form we know today as heat?

17. Distinquish between renewable energy resources and non-renewable energy resources. Give examples of each.

18. Which of the non-fuel energy resources are important now in the energy economy of the world?

19. What limitations exist with respect to the development of the following as great energy sources?

    tidal energy -

    wind -

    terrestial heat energy -

20. What success have we had in utilizing the sun as an energy resource?

21. Distinquish between "fusion" and "fission" in nuclear reactions.

    Which reaction would be more favorable in energy production?

    What disadvantages are there in using nuclear energy as an energy resource?

    What advantages are there is using nuclear energy?

22. Identify the physical quantities which must be measured in order to make a quantitative description of mechanical energy.

    What special relationship must exist between these two factors?

23. In 1967 a nuclear bomb was accidentally released in 2,500 feet of water as a result of a mid-air collision off the coast of Spain. A force of 2000 pounds was required to lift the bomb aboard a ship in two hours.

    a. How much work was done?

    b. How much horsepower did it take?

24. What is the difference between the gravitational system and absolute system of measurement?

25. Give three examples where measurements made in the gravitational system would be of little value.

26. What is weight?

    What factors affect the weight of a body?

    Can the weight of a body be zero? Explain.

27. How would the weight of a body be affected in each of the following situations?

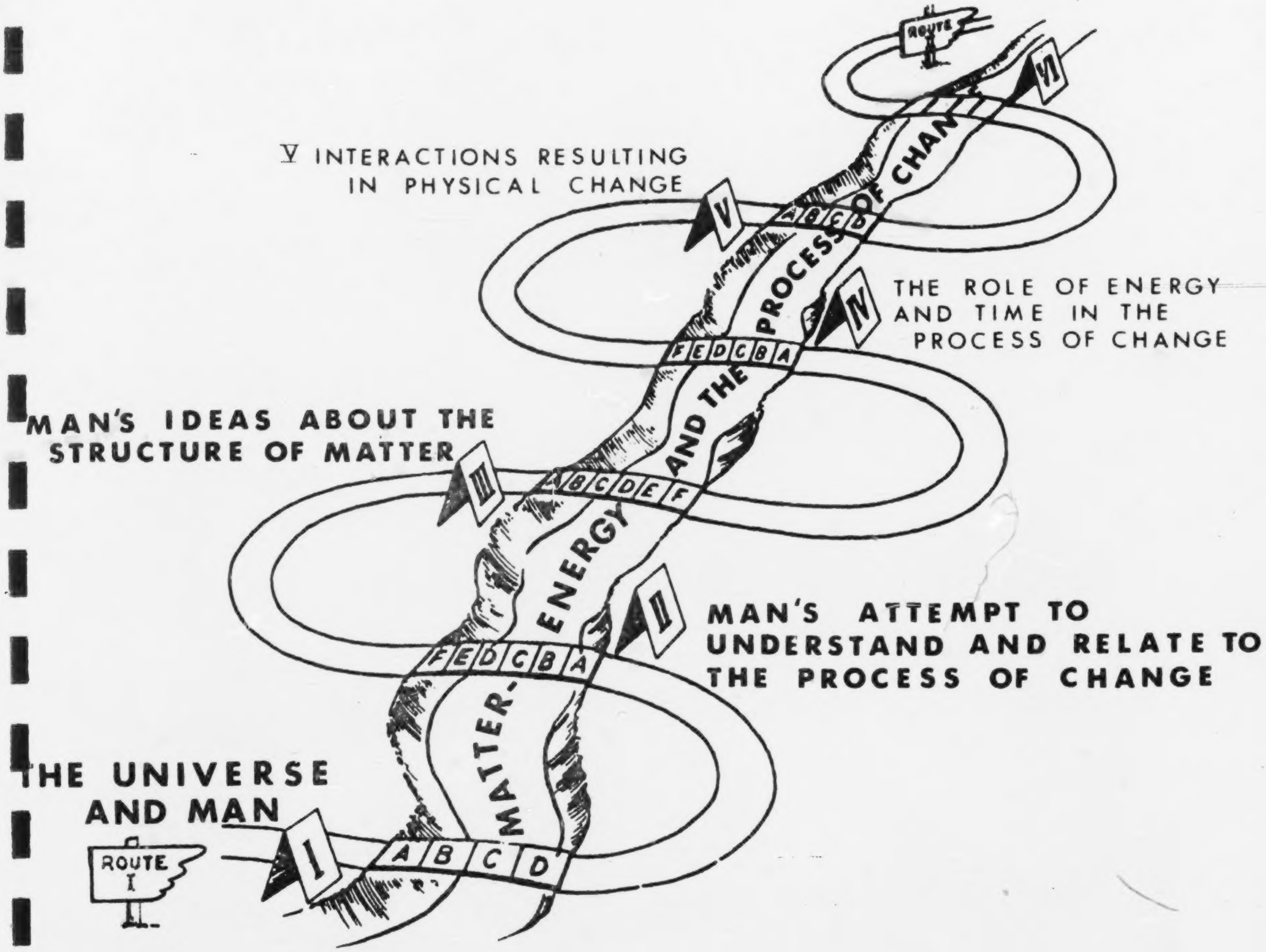
    a. if moved to a mountain top -

    b. if moved from the North Pole to the equator -

    c. while accelerated upward in a rocket -

    d. during reentry into the earth's atmosphere -

    e. if moved from the earth's surface to the center of the earth


ROUTE I
ROUTE I
V INTERACTIONS RESULTING IN PHYSICAL CHANGE
THE ROLE OF ENERGY AND TIME IN THE PROCESS OF CHANGE
MAN'S IDEAS ABOUT THE STRUCTURE OF MATTER
MAN'S ATTEMPT TO UNDERSTAND AND RELATE TO THE PROCESS OF CHANGE
THE UNIVERSE AND MAN
MATTER-ENERGY AND THE PROCESS OF CHANGE
I
II
III
IV
V
VI
A B C D
F E D C B A
A B C D E F
F E D C B A
A B C D

V. INTERACTIONS RESULTING IN PHYSICAL CHANGE.

A. Forces in the Universe Which Act to Effect Change.

B. Interactions Within Structures.

C. Physical Changes Resulting From Interactions

D. Interactions Between Macrostructures.

Forces in the Universe that Act to Effect Change

I. Forces and "Interaction"

   A. Relationship between force and energy

   B. Forces represented as "interactions"

   C. Measurement of force

      1. Systems

      2. Units

      3. Standards

GRAVITATIONAL			ABSOLUTE		
FPS	CGS	MKS	FPS	CGS	MKS

II. Familiar Forces at Work in the Universe

III. Classification and Comparison of Forces Involved in "Interactions"

FORCES	RELATIVE STRENGTH	AGENT OF TRANSMISSION
Strong Nuclear		
Electromagnetic		
Weak Nuclear		
Gravitational		

Characteristics:

A. Strong Nuclear

B. Electromagnetic

C. Weak Nuclear

D. Gravitational

FORCES OF COHESION WITHIN MACROSTRUCTURES

INTRODUCTION:

Macrostructures are held together by the forces of cohesion between the molecules or atoms which make up the structural body.

Suppose that we were to fasten a solid object in such a way that it could not be moved when external forces were applied to it. Careful observations would show that, under these conditions, the effect of the force would cause the object to become distorted.

The type of distortion that is experienced by a body depends upon the nature of the forces that act upon it. Forces that pull tend to stretch the object and distort its length in the same direction as the force. Forces that push tend to compress the body in the direction of the pushing force. Forces applied perpendicularly to the length of an object tend to produce bending distortions while forces applied in a circular motion result in a twisting type of distortion.

We know from experience that certain materials, like rubber, can be distorted by small forces compared to those required to distort steel objects of the same shape and size. The ability of any material to resist distortion is a special property of the material. This special property is so important, in terms of the usefulness of materials, that a physical quantity called "tensile strength" has been developed to compare the relative strengths of all materials. The tensile strength of any material tells how much force per unit area a particular material can sustain without permanently changing its shape.

All materials are elastic to some degree. We use the word "elastic" to describe the ability of a body to return to its original shape after the forces which cause distortion cease to act upon it. Unfortunately, the meaning associated with the word "elastic", in common usage, is quite different from the scientific definition of the word. For example, most people would say that rubber is more elastic than steel because rubber can be distorted through greater distances without permanent distortion. In this case, no consideration is given to the amount of force which produces the distortion. According to the scientific interpretation steel is much more elastic than rubber because steel can be subjected to much larger forces before becoming permanently distorted by the force.

The "elastic limit" for any material is defined as the maximum force it can sustain without becoming permanently distorted. The elastic limit for any material is measured in force units, pounds, grams, etc. If a long, very pure, copper wire was supported in a vertical position, it would be possible to gradually distort the wire along its length by adding weights to the bottom of the wire. As more and more weight is added, the space between the atoms of copper in the wire would increase slightly. We are able to observe this effect by noticing that the overall length of the wire increases. If we stop increasing the distorting force and then remove the weights from the wire, one of two things will happen. Either the wire will return to its original length or it will retain the length produced by the distorting force. If the wire returns to its original length, its elastic limit has not been exceeded. This means that within this interaction the cohesive force of attraction holding one copper atom to the next in the wire was greater than the distorting force attempting to pull them apart. In this case the distortion was only temporary because the elastic limit of the material was not exceeded.

If the wire had retained the length produced as a result of the distorting force, the force of distortion must have been greater than the cohesive force of attraction between the atoms of copper in the wire. In this case the wire was permanently stretched and some place along the length of the wire the diameter of the wire must have been decreased. We still have the same number of atoms but they are now spread out over a longer length. This represents a physical change in the dimensions of the wire. We now have, in effect, a different wire than the one we started with.

The tensile strength of any material is the maximum force that can be applied to a known cross sectional area of that material without exceeding its elastic limit. The tensile strength is usually represented as the lbs/in^2 or $grams/cm^2$ that a material can support without permanent distortion.

Within the limits of the elastic limit of any material the ratio of F/x is a constant number. In this ratio F represents the distorting force and x, the amount of distortion it produces on a particular wire.

The fact that the ratio of F/x is a constant value for any material, where F is less than the elastic limit of the material, was first observed by Robert Hooke. Hooke was an English physicist who lived from 1635 to 1703. He is considered to have been the greatest experimental scientist of his generation. This relationship, $k = F/x$, is known today as "Hooke's Law". It is also frequently referred to as the "Force Constant" for bodies subjected to forces within their elastic limit.

The limiting factor in this relationship is that the constant applies only to the particular body for which F/x has been measured. The particular value of the constant determined for a steel wire would be true only for that particular wire. It would not be true for another steel wire, even though its composition were exactly the same, unless this second wire was of exactly the same length and has the same cross sectional area.

A modification of "Hooke's Law" which takes into account the length and cross sectional area of the material is called the "Elastic Modulus" or "Young's Modulus", in honor of Thomas Young (1773-1829) who first proposed the idea. The elastic modulus is written as $Y = Fl/xA$, where l is the length of the member and A its cross sectional area. When these parameters are included in the ratio of F/x, the constant "Y" obtained is true for any sized object composed of that particular material. This is a much more useful form of this physical relationship.

INTERACTIONS RESULTING IN PHYSICAL CHANGE

INTERACTIONS WITHIN MACROSTRUCTURES

I. Forces of cohesion

   A. Distortion of structures in response to forces

   B. Special properties of solids relative to forces of cohesion

      1. tensile strength

      2. force constant

      3. elastic limit

      4. elastic modulus

   C. Special properties of liquids

      1. surface tension

      2. boiling point

Laboratory Problem

FORCES OF COHESION IN LIQUIDS

Experience has shown that liquids exhibit some unique properties due to the forces of cohesion that tend to attract the molecules in solution. We have seen, for example, that the surface of liquids are able to support objects whose weight forces downward are several times greater than the weight of the fluid they displace. It is apparent that forces other than the buoyant force exerted by the liquid are involved here. The additional force required to support the object is due to the force of cohesion between the molecules result in the phenomena which we call surface tension.

Surface tension and, in particular, the forces of cohesion between molecules in the liquid state are extremely important in the development of understandings relative to many processes that we will be investigating in the future. For this reason we need to examine the nature of cohesion in liquids rather carefully.

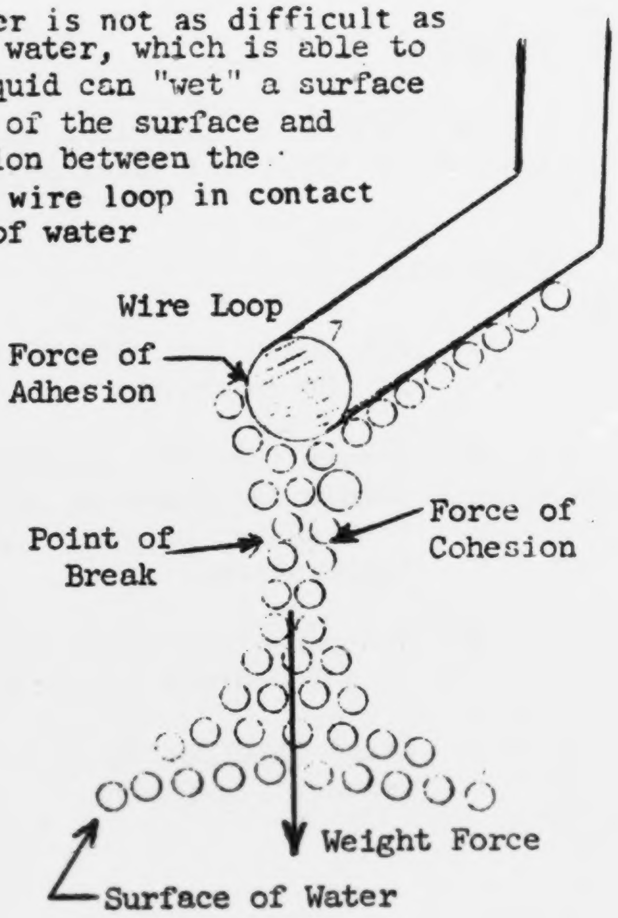
Experiments show that the surface of a liquid acts somewhat like a stretched rubber membrane. It tends to contract to the smallest possible area. This is what we should expect if there is a strong force of attraction between the molecules in the liquid. Consider the forces of cohesion on one molecule within the body of a liquid. Since the molecule is surrounded on all sides by other molecules, there are equal forces pulling it in all directions. These forces will add, vectorially, to zero and the molecule is left free to move through the liquid.

A molecule at the surface, however, has forces pulling it down and in a horizontal direction but none pulling it upward. The molecule is therefore free to move along the surface or down into the liquid but not up into the air. Since the molecules on the surface pull on each other in a horizontal direction, they tend to pull themselves together to form the smallest possible area of surface. The molecules will therefore pull themselves into the form of a sphere if freed from the forces of cohesion exerted by the surrounding molecules in the body of the liquid.

The magnitude of the force of cohesion between molecules in liquids is different for different liquids. The force of cohesion between water molecules, for example, is greater than that between molecules of alcohol and much greater than that between molecules of ether. In order to make quantitative measurements of these cohesive forces between molecules it is necessary to find some way to actually measure the force required to separate one molecule from another. Since it is not very easy to isolate two molecules of any substance, the forces of cohesion are always measured with reference to a known "length of line" of surface. If the diameter of the molecule is known it is then possible to determine approximately how many molecules are involved and to relate this number to the length of the line measured.

The surface tension of any liquid is defined as $ST = F/d$, where F is the force required to break a line of surface one molecular layer thick, of length d. If the surface tension for a liquid is known, one can calculate the force of cohesion between a pair of molecules, $F = ST \cdot d$; where d is the length of the line of surface broken.

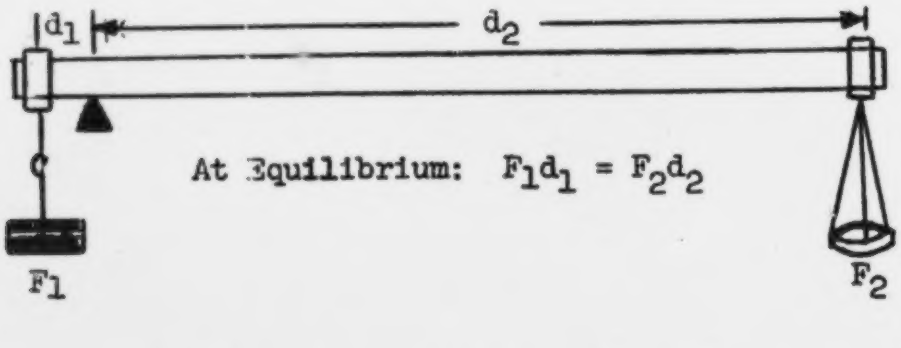
The problem of measuring the force on a monolayer is not as difficult as it might first appear. Consider a liquid, like water, which is able to "wet" the surface of another substance. Any liquid can "wet" a surface if the forces of adhesion between the molecules of the surface and the liquid are greater than the forces of cohesion between the molecules of the liquid. If we were to place a wire loop in contact with the surface of a body of water, molecules of water would be attracted to the metal. The water would "wet" the surface of the wire loop. If we now raise the loop, carefully, off of the surface of the water, we will be lifting, now only the loop and the water molecules in contact with the metal, but also several more layers of water molecules which are held to each other by forces of cohesion. As the loop is raised higher and higher the weight of the water being dragged along eventually reaches a point where the weight force downward equals, and then exceeds, the force of cohesion between the water molecules. Also, as the loop is raised the film of water is stretched until it becomes just two molecules thick.



When the film finally breaks it will break at that point where the film has the smallest force of cohesion opposing the greatest weight force downward. (See drawing) This would have to be a film two molecules thick at the point indicated.

With reference to this method of raising a molecular film above the surface of the liquid the value for d in the definition for surface tension, $ST = \frac{F}{d}$, becomes twice the circumference of the loop. This value represents the length of the line of surface, one molecule thick, which is broken.

The force can be measured by means of an "unequal" arm balance as shown below. The ratio of the forces in an "unequal" arm balance is inversely proportional to the ratio of the lengths of the arms.



After establishing equilibrium of the balance with the loop or ring in air, the ring can then be placed in contact with the surface of the liquid and the force required to break the surface of length "d" measured.

PROBLEM:

Determine, by experimental procedures, a value for the surface tension of distilled water at room temperature.

QUESTIONS:

1. How would the value for the surface tension of water be affected if the temperature were increased? Explain.
2. Assume that the diameter of a water molecule equals 3Å. Calculate the force of cohesion between two water molecules. Base your answer on your measured value for the ST of water at room temperature.
3. How would the value for the surface tension of water be affected if a few drops of alcohol were added to the liquid? Explain.
4. Could this method be used to measure the surface tension of mercury? Explain.

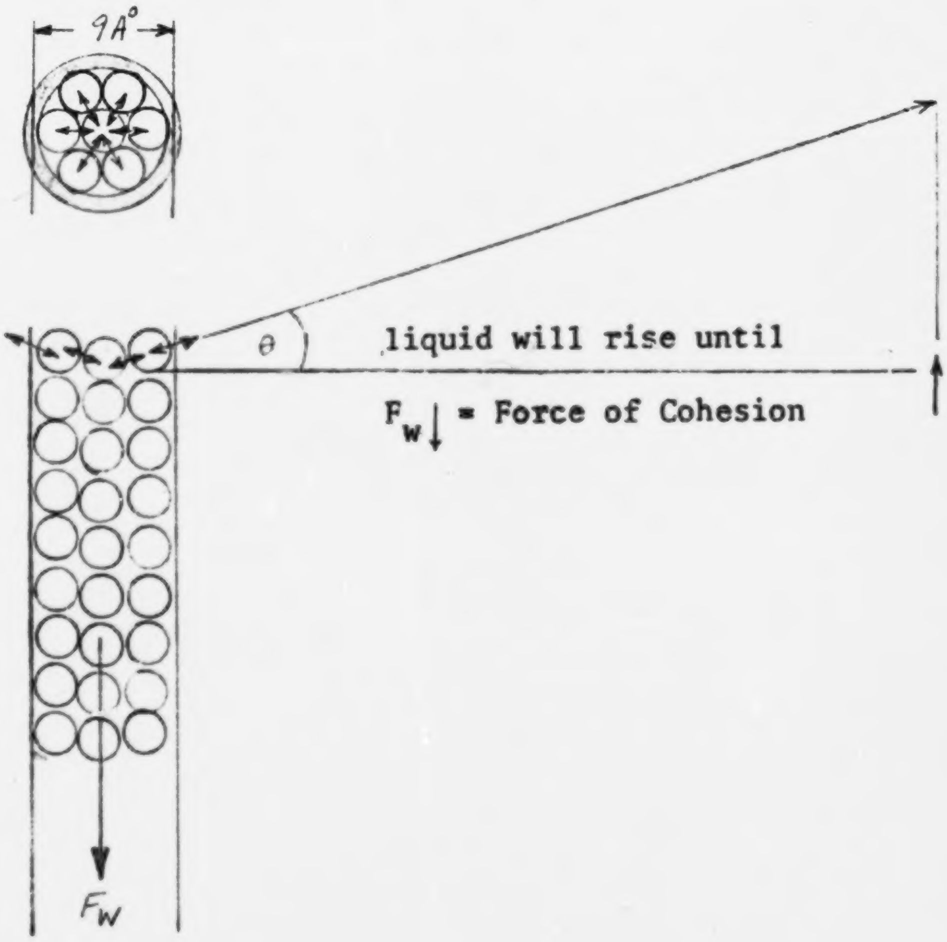
Interactions within Macrostructures (continued)

II. Forces of Adhesion

A. adhesion between solids

B. adhesion between solids and liquids

1. capillarity


9A°
θ
liquid will rise until
$F_w \downarrow$ = Force of Cohesion
F_W

Assume bore of tube equals 9 Ångstrom diameter

Diameter of water molecule equals 3 Ångstrom

6 water molecules surround one central molecule

$$S.T. = \frac{F}{d}$$

2. examples of capillarity in nature

INTERACTIONS WITHIN MACROSTRUCTURES, Contd.

Electrostatic and Magnetic Interactions

Resource Material:

Required Reading:	Modern Physics, Chapter 18, Electrostatics, pages 381-406; Chapter 21, pages 462-472
Recommended Reading:	Basic Science Series, #200-8, Chapters 1 & 2 Magnets, Francis Bitter "Magnetic Fields and Life", Science World, Nov. 7, 1962, pages 4-7

QUESTIONS FOR CONSIDERATION:

1. What is electric charge?
   How is an electric charge produced?
   Describe the units used to measure electric charge.

2. Discuss the meaning of electrical potential.
   When does an electrical potential exist?
   Why is the earth considered to be a body with a continuous "zero" electrical potential?

3. Can any type of matter become electrically charged?
   What factors effect the ability of a body to become charged?
   To retain an electric charge?

4. What is the difference between static electricity and current electricity?

5. What is a magnetic pole?
   Where are they located?
   What is magnetic pole strength?

6. Can any type of matter be made to exhibit magnetic properties?

7. Discuss the "Domain Theory" of magnetism.

8. In what way are the forces associated with magnetism similiar to gravitational forces?

9. What is a "line of force"?
   Do lines of force actually exist?
   What are some of the properties of lines of force?
   Are there lines of force associated with gravitational force fields?

10. What is meant by magnetic field strength?
    What factors affect magnetic field strength?
    Describe a technique which could be used to measure the intensity of a magnetic field.

Electrostatic Forces

I. Electrical Properties of Matter

  A. Basic Assumptions in Atomic Theory Which Relate to the Electrical Properties of Matter.

  B. Discoveries Leading to the Development of Early Theories About the Nature of Electiricity.

    1. Thales (640 B.C. - 546 B.C.)

    2. William Gilbert (1544 - 1603)

    3. OttoVan Guericke (1602 - 1686)

  C. Classification of Matter on the Basis of Electrical Properties

    1. Conductors

    2. Non Conductors

    3. Semi Conductors

II. Electric Charge

  A. The Nature of Electric Charge

    1. Definition and Units

    2. Franklin's Theory

B. Methods of Producing Electric Charge

1. Conduction

2. Induction

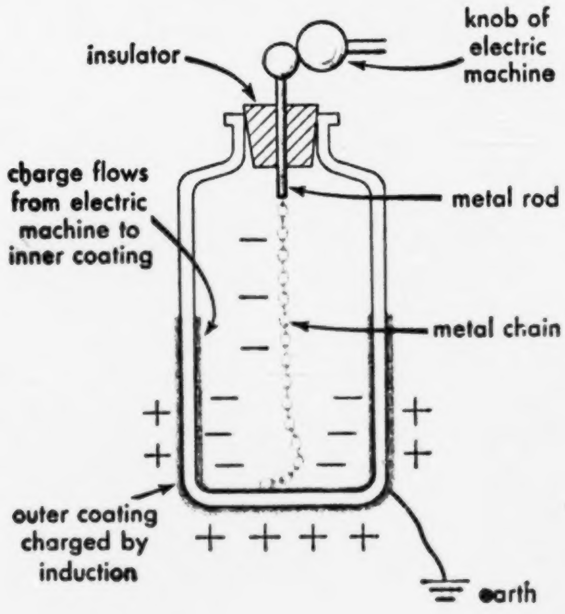
3. Mechanical Devices

a. Wimshurst machine

b. Van de Graaff Generator

C. Methods of Detecting Electric Charge

Charging a Leyden jar condenser.


knob of electric machine
insulator
charge flows from electric machine to inner coating
metal rod
metal chain
outer coating charged by induction
earth
+
−

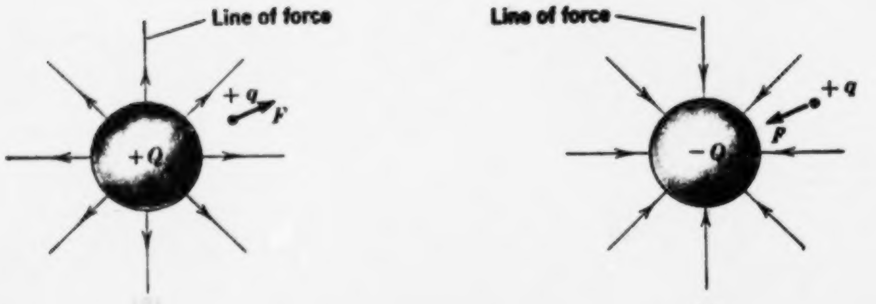
D. Storage and Transfer

1. Electrical Potential

2. The Earth as a Conductor

E. Electric Field Strength

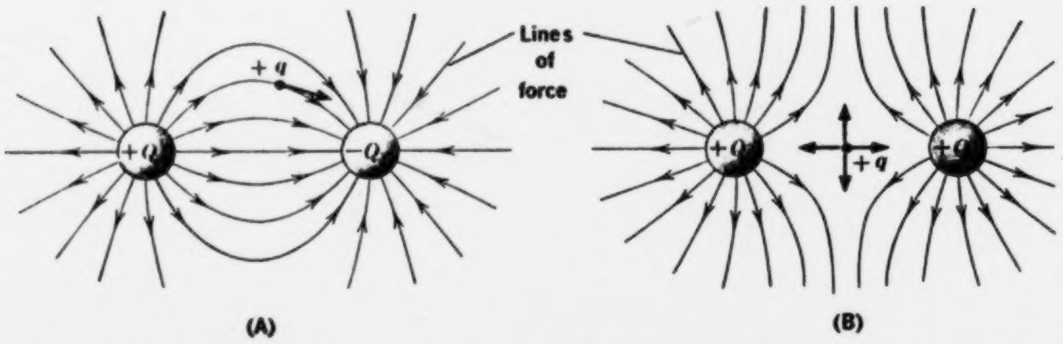
1. Forces Between Charged Bodies


Line of force
+q
F
+Q
Line of force
+q
F
−Q

(A) (B)

The electric field surrounding a charged sphere isolated in space.

2. Interaction of Forces


+q
+Q
−Q
Lines of force
+Q
+q
+Q

(A) (B)

Lines of force show the nature of the electric field near two equal charges of opposite sign (*A*), and near two equal charges of the same sign (*B*).

Laboratory Investigation

THE ELECTRICAL PROPERTIES OF MATTER

INTRODUCTION:

All matter is composed of fundamental particles which are electrically charged. Electric charge is an undefined physical quantity. Like time, length and force, electric charge cannot be defined but it can be experienced directly via the senses and it can be measured.

It is a natural tendancy for all matter to be electrically neutral, that is, to maintain an equality between the number of + protons and - electrons. However, it is possible to cause - electrons to be added to or taken away from a body and disturb the electrical equilibrium of the system. When this happens the system is said to be electrically charged. If the system has lost electrons it is positively charged, when a system gains electrons it becomes negatively charged.

When a charged body is brought near an uncharged conductor a separation of charges occurs, actually a movement of electrons in the uncharged body. The displacement of electrons as a result of the influence of a charged body near, but not in physical contact with a conductor is called "electrostatic induction". If a conductor is momentarily grounded, while in the presence of a charged body a charge, opposite in sign to that of the charged body, will remain on the conductor. This process is called charging by induction.

Often the foregoing phenomena are explained on the basis of the repulsion and attraction of like and unlike charges respectively. However, it is more desirable to base the explanation on the fundamental idea of "electrical potential".

Electrical potential may be described as the factor which governs the flow of electrons (electricity) between two bodies, or between two points in space. No electrons can move from one point to another unless there is a difference in electrical potential, that is, a difference in the magnitude of the electric charge between the points sufficient to drive the electrons from one point to the other.

The electrical potential of a body depends upon a number of things; its charge, its capacity to hold a charge, and its position relative to neighboring charges. The presence of a body with a negative charge has the effect of lowering the electrical potential of all neighboring charges. The presence of a body with a positive charge raises the electrical potential of all surrounding bodies.

The electrical potential between any two points in space varies with the distance between the points and with the magnitude of the electric charge which resides at each point. The potential at any point within the boundries of a spherical or cylindrical conductor is the same everywhere so long as the conductor is not actually transferring electrons.

One extremely important aspect of the theory of electrical potential has to do with the earth and all matter physically attached to it. The earth is so large compared to isolated systems on its surface that it is regarded as an inexhaustible source of electrons, or a limitless "sink" into which electrons can be poured without changing its electrical potential. At the same instant that electrons are being taken from the earth at one location, electrons are being returned to the earth at some other location. The result of this type of exchange is that the electrical potential of the earth, in total, remains unchanged. One can consider the earth to be somewhat like a non-profit "world bank" for electrons. An electron exchange goes on constantly as a result of deposits and withdrawals all over the world, but the books always balance. In total, the number of electrons being withdrawn are always equal to the number being returned and consequently the potential of the earth is always zero. This idea of regarding the earth as having a constant zero potential is fundamental to our understanding of modern electrical theory.

PURPOSE OF THE INVESTIGATION:

Our purpose in this experiment is to investigate the phenomena of electric charge which are basic to an understanding of the electrical nature of matter. Specifically we will be concenred with:

a. the production and transfer of electric charge by conduction and induction methods
b. the detection and identification of electric charge by use of a precision gold leaf electroscope
c. the distribution and retention of charge on various types of conductors.

PROCEDURE:

Each of the investigations described should be performed two or three times and the results noted and discussed by members of the group. The experiment report will consist of diagrams which show a quantitative distribution of charge on the various conductors. Represent a neutral electroscope with three + charges and three - charges. Represent all charged bodies by showing an excess of one + or - charge as the case may be. When electrons move along a conductor represent the direction of the motion by use of arrows.

a. When leaves of the electroscope are diverged, a potential difference exists.

b. When electrons move, the leaves in an electroscope will move.

PRECAUTIONS:

1. The gold leaf electroscope is a very sensitive instrument capable of detecting extremely small differences in electrical potential. Do not bring a highly charged body in direct contact with the instrument since a sudden excess charge will tear the gold leaves apart.

   While using the electroscope maintain a ground connection between the case and the earth.

   When you are through using the instrument, charge it slightly and replace the cap.

2. Do not touch the knob of a Leyden Jar Conden Condenser without grounding it first.

3. Handle all equipment carefully and with respect. Do not intentionally touch the surfaces of conductors and insulators, since moisture and oil detract from their ability to function properly.

Laboratory Investigation

Name ______________________

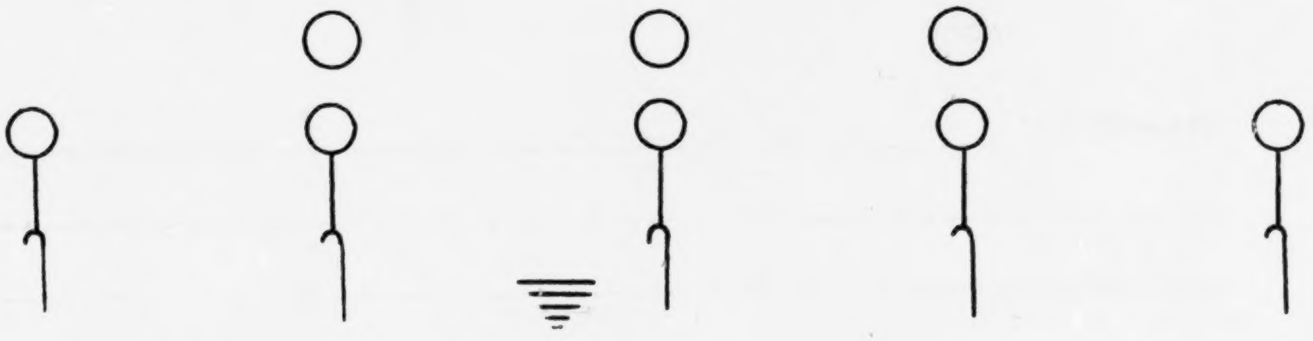
Science IA Hour ______

Date ______________________

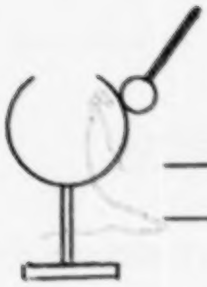
THE ELECTRICAL PROPERTIES OF MATTER

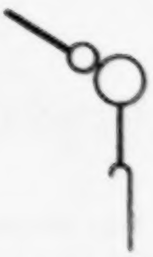
PART ONE: PRODUCTION AND TRANSFER OF ELECTRIC CHARGE BY CONDUCTION AND INDUCTION METHODS

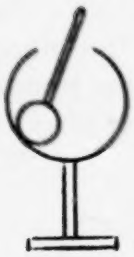
1. Ground the case of the electroscope to the gas pipe with a fine copper wire. Charge a hard rubber rod by buffing its surface with fur or wool. Charge the electroscope by INDUCTION. Note, carefully, the behavior of the leaves during each step in the procedure. Complete the diagrams below, illustrating each step of the procedure. Also, indicate the "charge" and "potential" of the electroscope for each step of the procedure.

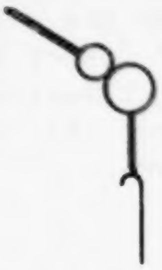


2. Charge the spherical conductor by bringing it near the Van de Graaf generator. Touch an uncharged proof plane to the outside of the sphere and then touch the proof plane to an uncharged electroscope. If the leaves diverge determine the sign of the charge on the electroscope. Repeat these operations several times, touching different points, both on the outside and the inside of the hollow sphere. Illustrate the results with a diagram and summarize the results with a statement describing the distribution of charge for a hollow conductor.



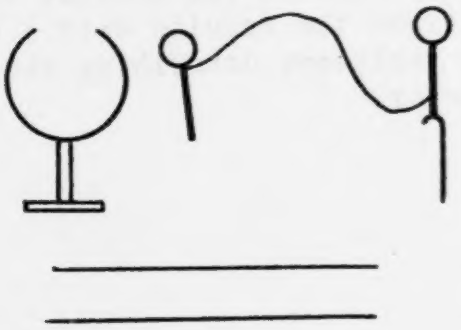






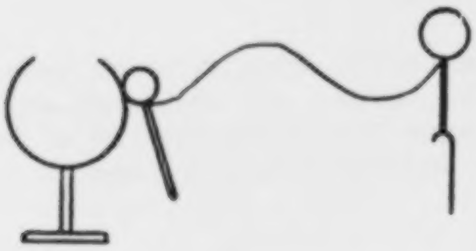
Statement:

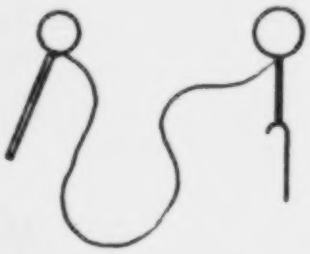
3. Connect the proof plane to the electroscope with a fine copper wire. Make sure that the proof plane and the electroscope are initially uncharged, then bring the proof plane near the charged sphere. Be careful to prevent the wire from touching your hand, the table top, or anything else. Determine the sign of the charge on the sphere. Determine the sign of the charge on the leaves of the electroscope. Complete the sketch, showing the distribution of charge on the sphere, the electroscope, and the proof plane. Indicate the charge and the potential for the electroscope.



Name ______________________

Next, carry the proof plane closer to the sphere and finally touch the outside surface of the sphere with the proof plane. Make a diagram showing the charge distribution and electron flow. Remove the proof plane and make a second sketch showing the final charge and potential on the electroscope.





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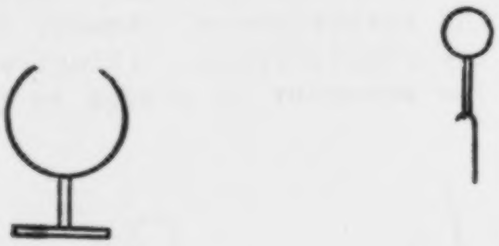
4. Repeat the operations in part 3, but this time carry the proof plane inside the opening of the sphere. Be careful not to touch the edge of the opening with the proof plane or with the wire. Make a set of three drawings to show the charge distribution on the sphere, the proof plane and on the electroscope for the following situations:

a. proof plane inside the sphere without any contact between the plane and the sphere



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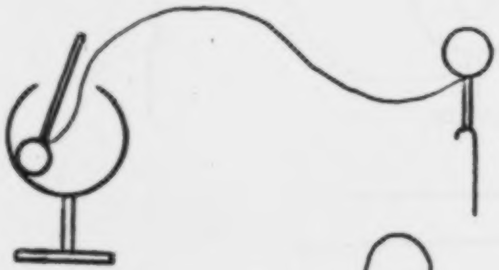
b. proof plane in contact with the inside surface of the sphere



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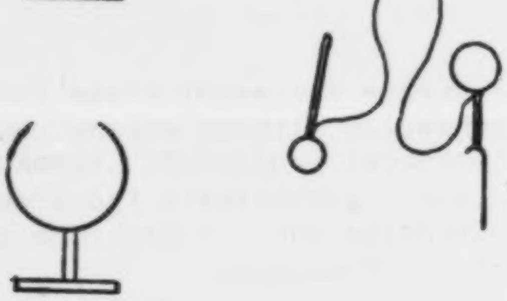
c. proof plane removed, after contact with the interior of the sphere



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Make a concluding statement summarizing what you have learned about the distribution of a charge on a body.

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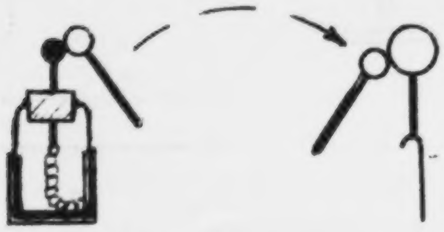
PART TWO: POTENTIAL DIFFERENCE AND DISTRIBUTION OF CHARGE

1. Charge the Leyden Jar by holding the base in your land and placing the knob in contact with the sphere on top of the Van de Graaf generator. The jar serves as a container for a supply of charge which can be carried to your table and used as needed during the course of this part of the experiment.

   Transfer a small amount of charge to the electroscope by touching the proof plane to the knob of the Leyden Jar and then to the electroscope. Make a sketch showing the distribution of charge on the Leyden Jar, the proof plane, and the electroscope.



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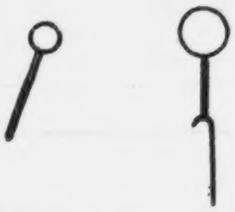

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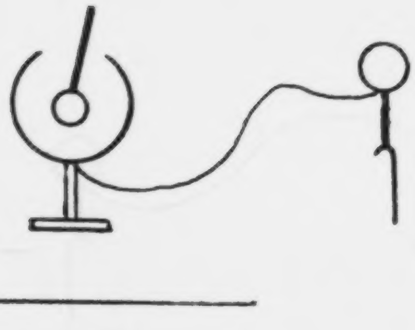
2. Connect the uncharged electroscope to the insulated hollow sphere which will serve as your "ice pail". Give the proof plane the same charge as that on the knob of the Leyden Jar and introduce it into the hollow sphere. Be careful not to make contact with the sides of the spherical conductor. Test the sign of the charge on the electroscope. Remove the plane carefully. Note the behavior of the electroscope. Illustrate the action with a sketch and describe the movement of charge in the systems.



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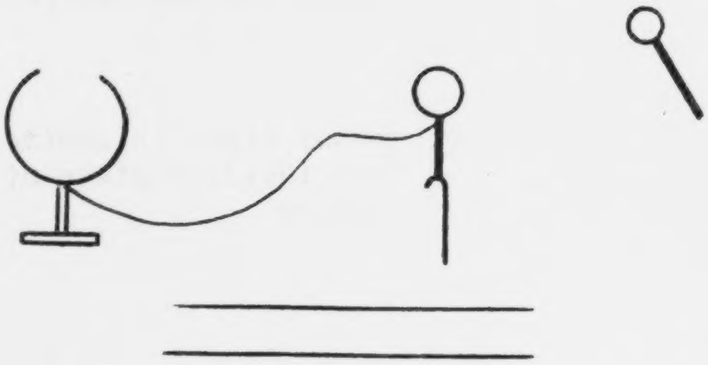

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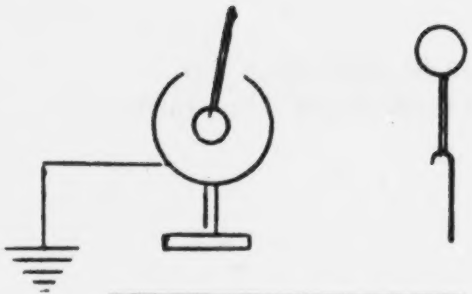
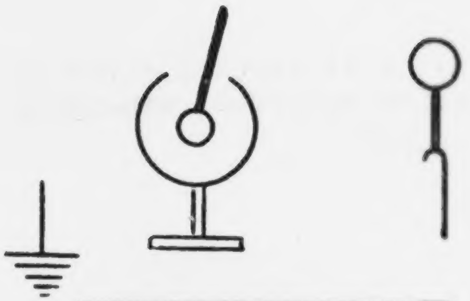
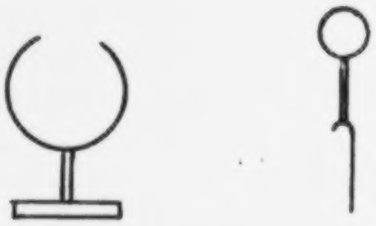
3. Recharge the proof plane and again introduce it into the hollow conductor without making contact with its surfaces. Ground the spherical conductor. Break the ground and then remove the proof plane. Investigate the sign of the charge on the electroscope. Discharge the electroscope and the conductor. Diagram the electron motion observed.

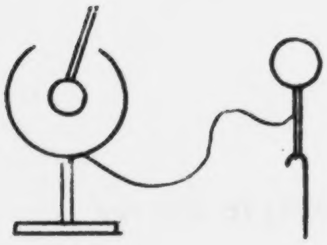
Name ____________________________

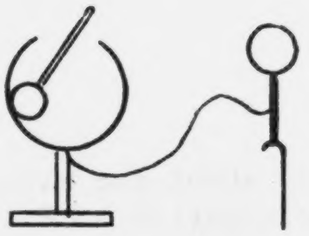


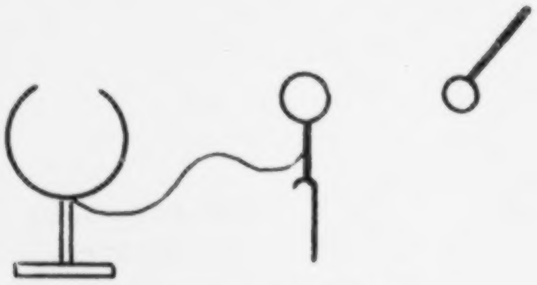




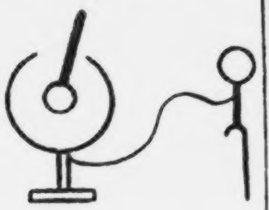
4. Recharge the proof plane and place it inside the conductor. Now let it make contact with the inside surface and note the divergence of the leaves of the electroscope. Remove the proof plane and determine the charge on the electroscope. Determine the sign of the charge on the proof plane. Discharge the electroscope and the spherical conductor. Diagram the results.

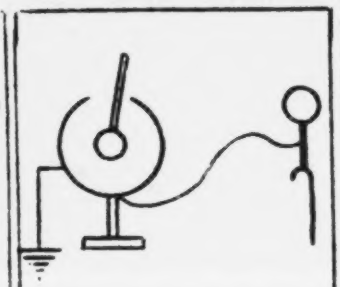


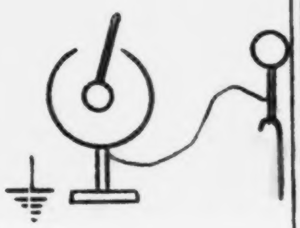


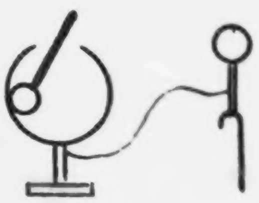


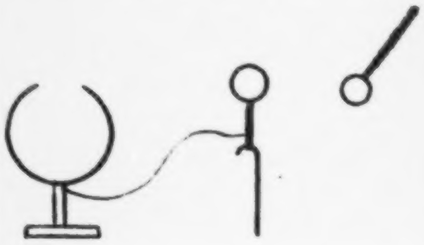
5. Recharge the proof plane again and introduce it into the spherical conductor without making contact. Ground the conductor. Break the ground. Touch the proof plane to the inside of the conductor and note carefully the behavior of the leaves of the electroscope. Remove the proof plane. Diagram the results.











QUESTIONS:

1. A small proof plane is touched first to the outside and then to inside of a charged spherical conductor. Does it acquire the same charge in each case?

   Is it, while in contact with the conductor, at the same potential in each case?

2. If the leaves of an electroscope are slightly diverged, how could one tell, without touching it, whether the divergence was due to rigidity of the leaves or due to a slight charge?

3. Identify four basic ideas about the nature of electric charge illustrated in this investigation.

4. Is it possible for a body at zero potential to have an electric charge? Explain.

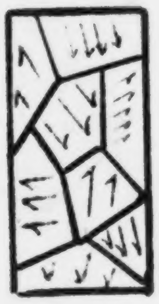
Magnetic Forces

I. The Theory of Magnetism

   A. Magnetism - A Property of Electric Charge in Motion

   B. Electron Motions

      1. Orbital Motion



      2. Spin

      3. In Magnetic Materials

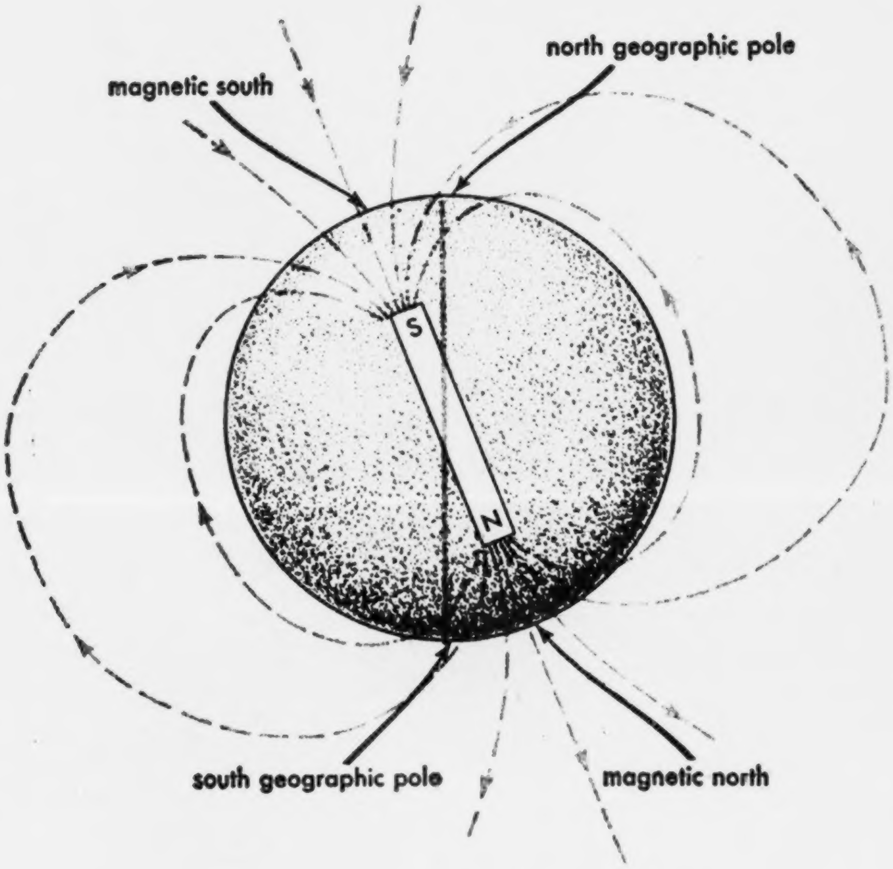
   C. Magnetic Domain

   D. Magnetic Poles

      1. Definition

      2. Location

   E. The earth as a Magnet


north geographic pole
magnetic south
S
N
south geographic pole
magnetic north

The earth behaves as though it were a huge magnet.

II. The Detection and Measurement of Magnetic Forces

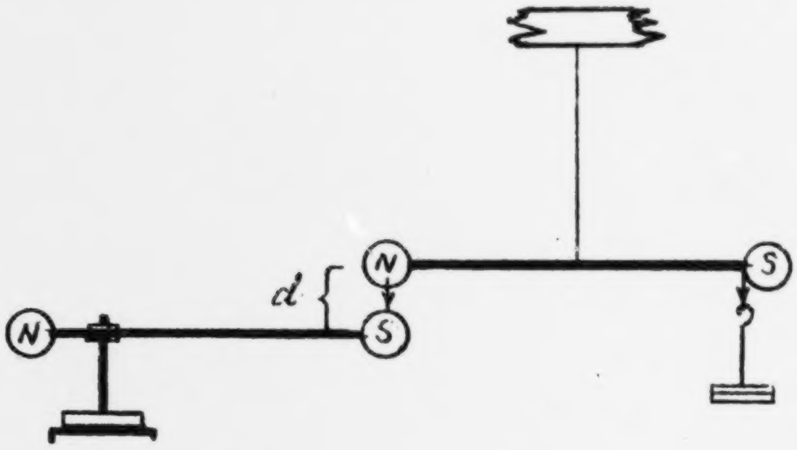
A. Magnetic Pole Strength

1. definition

2. establishment of units

B. Factors which affect the magnitude of magnetic forces

Force F_1	Distance	Fd^2



C. Similarities Between Gravitational, Electrostatic and Magnetic Forces.

1. Newton's Law of Universal Gravitation

2. Coulomb's Law of Electric Charge

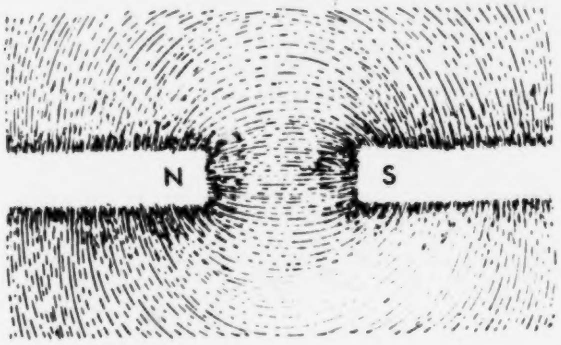
3. The Law of Magnetic Pole Strength

I. Resultant Forces in Magnetic Fields

A. Lines of Force

1. Properties of Lines of Force

Lines of force pass from the N-pole of one magnet to the S-pole of an adjacent magnet.

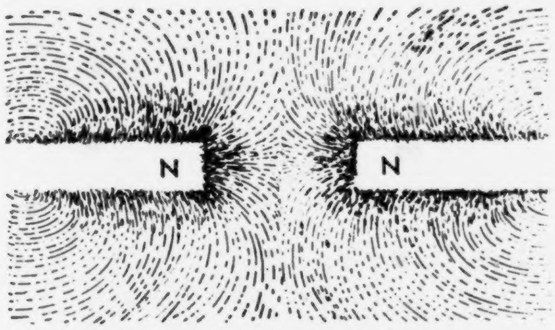


2. Detection

B. Forces between Magnetic Poles

C. Magnetic Field Strength

1. Definition and Units

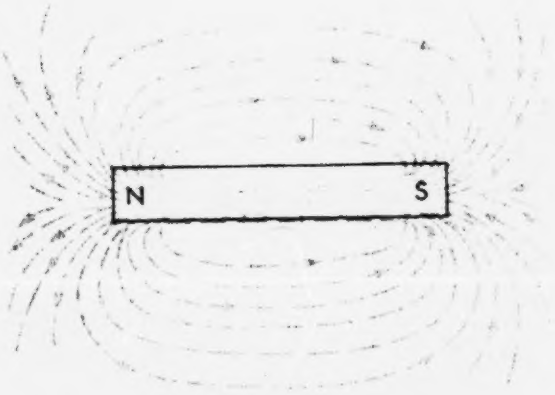


Magnetic lines of force between two poles of the same kind repel each other.

2. Factors Which Affect the Magnetic Field Strength at Any Point in Space

D. Interactions in Magnetic Fields

1. Effect of Earth's Magnetic Field



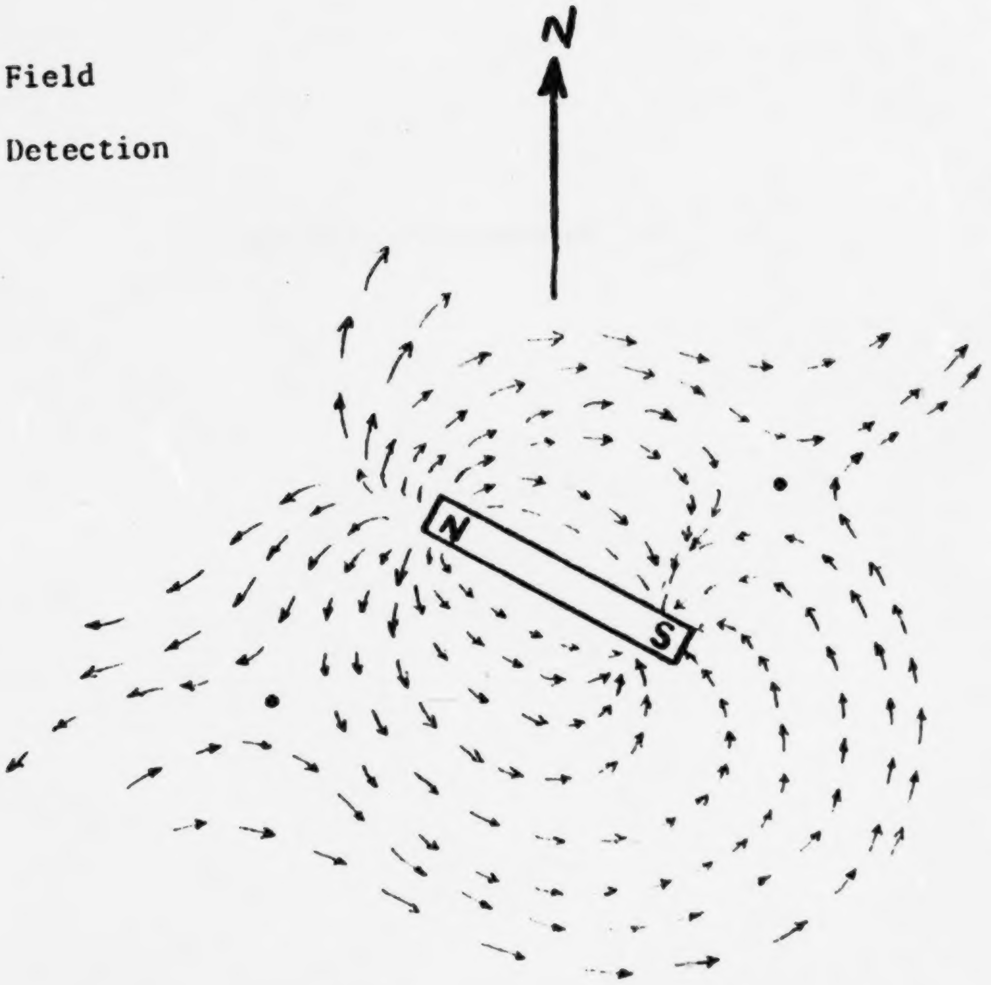
A magnetic field (shown by lines of force) surrounds a bar magnet.

2. Magnetic Feild Strength at Any Point in Space

3. Neutral Points

4. Local Magnetic Field

   a. Methods of Detection



   b. Plotting of Magnetic Force Fields

II. Magnetic Fields & Life

A. Sensory Response to Magnetic Lines at Force

B. Biomagnetic Effects

Laboratory Problem

INTERACTION OF FORCES IN MAGNETIC FIELDS

INTRODUCTION:

The lines of force associated with magnetic fields of an isolated bar magnet do not form the smooth curves and neat geometric patterns usually pictured or described in books. This sort of non-distorted field probably does not exist anywhere in nature. Magnetic fields ranging outward from the poles of a magnet interact with other magnetic fields. The earth itself is a huge magnet and has a magnetic field which encompasses the entire globe. It is not possible to escape the influence of the magnetic forces associated with the earth's magnetism.

The magnetic field strength in the vicinity of a magnet is inversely proportional to the square of the distance from the poles. The intensity of the earth's magnetic field in Dane County is approximately equal to the field strength at a point 90 centimeters from a magnetic pole which has a strength of 800 unit poles. If you were to explore the magnetic field of such a magnet at this distance from its poles you would find it extremely difficult to distinquish between those lines of force associated with the bar magnet and those which are a part of the earth's magnetic field.

PROBLEM:

1. Plot the resultant magnetic field surrounding a bar magnet and locate the two points where the resultant field strength is zero.
2. Calculate the pole strength for both the North and South poles of the bar magnet.

THEORY:

Magnetic field strength is a vector quantity having the same direction as the resultant force between magnetic poles.

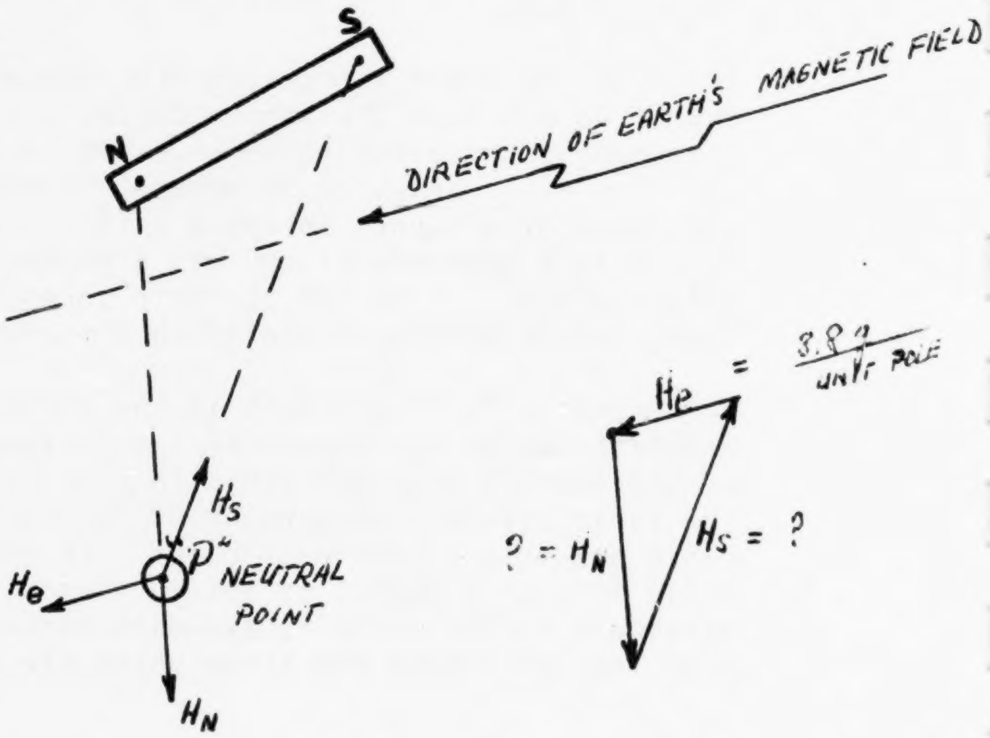
$$\underset{\leftarrow}{H} = RF/m$$

Whenever two magnetic fields "overlap" the interaction of forces that takes place causes the lines of force within the magnetic field to become distorted. The amount of distortion depends upon the relative direction and magnitude of the interacting forces. In the area very close to the magnet the force of the earth's field has little effect on the lines of force associated with the bar magnet. Further away, where the field strength of the bar magnet drops off to values on a par with those in the earth's field, the distortion will be very significant.

For every bar magnet, interacting with the earth's magnetic field two neutral points exist. That is, two points where the relative strength and direction of the interacting forces is such that the resultant field strength is zero.

At a "neutral point" such as that shown at the right, the total force experienced at that point is zero, because the horizontal component of the earth's field H_e, is exactly equal in magnitude, but opposite in direction, to the field at "P" caused by the bar magnet.

The North pole of the bar magnet will produce a magnetic field strength "H_N" at the neutral point "P" in the direction of NP - the South pole produces a magnetic field strength "H_s" in the direction of PS.



The resultant of these two vectors, plus "H_e", the field strength due to the magnetic pole strength of the earth, gives the resultant magnetic field strength.

The value for the earth's magnetic field strength (H_e) in this area equals 8.8g/unit pole. After the neutral point has been located the value for the magnetic field strength due to the N and S poles of the bar magnet can be found. The value for H_N↓ and H_s↑ is directly proportional to the length of the vectors representing these field strengths on the drawing. By measuring the length of the vector H_{α} and setting this number of centimeters equal to 8.8 the values for H_N↓and H_s↑ can be determined.

Magnetic field strength is defined as:

$$H = \frac{R.F.}{m}$$

however, since $R.F = \frac{\alpha m^2}{d^2}$

then H at any point equals:

$$H = \frac{\alpha m^2}{d^2 \cancel{m}} = \frac{\alpha m}{d^2}$$

$$\therefore m = \frac{Hd^2}{\alpha} \quad \text{or} \quad m_N = \frac{H_N d^2 N}{\alpha} \quad \& \quad m_s = \frac{H_s D s^2}{\alpha}$$

d = distance from neutral point to poles. (CM)

The N and S magnetic pole centers are considered to be located slightly inside the ends of the magnet at points 1/12 of the length of the magnet in from the end.

PROCEDURE:

Fasten a large sheet of paper to the desk top with tape. Place the bar magnet with its axis parallel to the length of the paper and near the center of the sheet. Trace an outline of the magnet on the paper. Locate the pole centers and indicate the polarity. Draw a line on the paper which represents the direction of the earth's field. Place a small compass near the north pole of the magnet and make dots as near each end of the needle as possible and in line with it. Move the compass in the direction in which its north pole points until the south pole of the needle is above the dot previously made at the north pole and make another dot at the north in its new location.

Continue until the series of dots leads to the south pole of the bar magnet or near the edge of the paper. Draw a smooth curve through the points and indicate, by arrows, the direction of the field.

In a similar way trace other lines of force until the field is clearly represented on all sides. Successive lines may be originated from any point near the permanent magnet. Continue the "mapping" until lines have been traced far enough from the magnet to show the undisturbed field of the earth.

Two places should be found where the direction taken by the compass needle is indeterminate; places where the compass needle does not seem to assume any specific direction. These positions are called "neutral points", and the region in this vicinity should be mapped with great care. The field near these points is very weak and is zero at the precise point of neutrality.

Do not use a pencil which is incased in metal until it has been determined that the metal does not effect the compass reading.

Locate both neutral points and use the magnetic map to calculate the pole strength for the north and south pole of the magnet.

Current theories of magnetism suggest that the pole strength at the north and south pole centers of a magnet must be equal. Thus, if the two neutral points are precisely located, the calculated values for the north and south pole strengths would be equal.

ANALYSIS OF DATA AND CONCLUSION:

Compute the values for the north and south pole strengths of the bar magnet based on the location of the neutral points. Determine the percentage difference between these values and also the average value for the pole strength of the bar magnet. Show all vector diagrams, equations, and substitution of values on the map which represents the resultant field. Label each vector. Summarize your results and answer the questions shown below on the back of your drawing.

QUESTIONS:

1. What happens to the strength of the magnetic field as the distance from the pole of a magnet is increased?

2. Discounting the effect of interaction between various magnetic fields, could you ever travel so far away from the pole of a magnet that the field strength due to the magnet would be zero? Explain.

3. Magnetic pole strength is undefined but it can be detected and measured. Magnetic field strength at any point in space is defined, H = RF/m. In describing the magnetic field around any magnet we talk about "lines of force". What is a magnetic line of force?

4. Why are there always two neutral points surrounding any magnet?

5. What would happen to the neutral points established in your experiment if a second bar magnet was placed near the edge of the paper?

INTERACTIONS BETWEEN MACROSTRUCTURES

INTRODUCTION:

"Pressure" and "Total Force" are words which we have used many times to describe the way in which various substances affect us because of their weight. Although these terms are more or less familiar in common usage their actual meaning in a scientific sense may not be clearly understood.

Pressure is defined as the Force per unit area acting upon any surface. The product of pressure and area is called "total force."

During the next few weeks we shall raise many questions relative to these two terms in an attempt to learn more about how and why solids and liquids exert pressure, how pressure and total force are measured, and some of the reasons why these physical quantities are so important to us..

The forces which bind atoms or molecules of matter in the solid state are large enough to restrict the motion of these particles to a specific location within the solid. The particles experience a type of vibratory motion, proportionate to their thermal energy, but they do not possess sufficient thermal energy to move about from one space to another within the confines of the solid. The result is that the pressure, (Force/Area), exerted by the particles in the solid. *The only significant external force exerted by a solid, at rest, is due to its weight. This weight force is a vector directed downward. The solid retains its shape and its entire weight force is applied against its base.

Since pressure is defined as $\frac{F}{A}$, the pressure exerted by a solid, at rest, is equal to the $\frac{\text{wt. of solid}}{\text{Area of base}}$

$$p = \frac{F_w}{A} \qquad \text{(for solids at rest)}$$

When the forces which bind the atoms or molecules of a substance together are too small to prevent these particles from flowing about freely the material is said to be in the liquid state. These conditions exist because the thermal energy possessed by the atoms or molecules is sufficient to produce a force/unit area (pressure) which continuously distorts the shape of the material. For this reason matter in the liquid state cannot be "contained" except by vessels which are able to withstand the pressure exerted by the molecules or atoms as they flow freely about within the material.

The question now arises; what is the pressure exerted by a liquid equal to? We know that pressure is defined as $p = \frac{F}{A}$ and, that for solids at rest the force is equal to the weight $\frac{F_w}{A}$, but is the force which a liquid exerts against a surface equal to the weight of the liquid? We have had enough experience in handling liquids to realize that in at least one case this cannot be true. Experience has shown that liquids exert pressure against the side walls of their containers. If a vessel is not able to withstand this pressure the liquid changes its shape and "flows."

Since weight force is a vector directed downward the Force exerted against the side → of the vessel cannot be the weight ↓ and for this case pressure does equal weight/area.

The amount of "total force" exerted upon a surface by any solid or liquid is directly dependent upon how large the surface area is and how much pressure is exerted against the surface. Thus, for both solids and liquids,

total force equals pressure x area.

$$TF = p \cdot A$$

We shall investigate the interaction of forces responsible for the pressure exerted by liquids and solids. Our purpose in these investigations shall be to determine what differences, if any, exist between the pressure exerted by matter in the liquid and the solid state and also how the total force exerted by solids and liquids compares to their weight.

Recommended Reading: Modern Physics, pp. 176-188

QUESTIONS FOR CONSIDERATION:

1. Discuss the difference between liquids and solids in terms of the molecular forces present.

2. What factors determine the pressure that a solid object will exert? How may these factors be represented to define pressure?

3. Explain why the total force exerted by a solid is equal to its weight. How is it possible that pressure times area can give the correct units answer for weight?

4. Does the total force exerted by a solid body always equal its weight? Explain.

5. Can the pressure exerted by a solid body be changed without changing the weight or shape of the body? Explain.

6. Show a sequential derivation by which it would be mathematically possible to represent the pressure of a body in terms of its density and height.

7. Explain why the product of D and height always gives the pressure exerted by a liquid but represents a special case for solids.

8. Discuss two techniques used to measure the pressure exerted by liquids.

9. In what way does liquid pressure on a horizontal surface differ from that exerted on vertical or slanted surfaces. How can you take these differences into account when representing a general equation for pressure exerted by liquids?

INTERACTIONS BETWEEN MACROSTRUCTURES

I. Pressure, Defined in the Terms of the Physical Quantities Force and Area

   A. Systems and units

   B. Standard

II. Adaptation of the General Equation to Describe Pressure

   A. Exerted by solids

   B. Exerted by liquids

III. The Relationship between Pressure and Total Force

   A. For solids

   B. For liquids

   C. Systems and units

IV. Measurement of Pressure

   A. Solids

   B. Liquids

Laboratory Problem

PRESSURE AND TOTAL FORCE

INTRODUCTION:

Pressure is defined as Force per unit area $\frac{F}{A}$.

The force exerted by solids at rest is equal to the weight. Thus, pressure exerted by solids is equal to wt/area of base.

$$\text{Density} = \frac{\text{weight}}{\text{volume}}$$

$$D = \frac{W}{V}$$

and; $W = D \cdot V$

For a rectangle, Volume = area x height

$$V = A \cdot h$$

thus $W = D \cdot A \cdot h$

pressure = $\frac{\text{Force}}{\text{Area}}$; and for solids at rest = $\frac{\text{Weight}}{\text{Area}}$

$$p = \frac{W}{A} = \frac{D \cdot \cancel{A} \cdot h}{\cancel{A}} = D \cdot h$$

Total force = pressure · area

$$\text{T. F.} = \text{p.A. or D.h.A}$$

The combination of equations above shows that although the definition for pressure is Force/area it may also be expressed as wt/area or height x density.

$$\left[p = \frac{F}{A}\right] = \frac{W}{A} = h \cdot D$$

Total Force, defined as F · A, may be expressed as Fw or D.h.A.

$$\left[TF = p \cdot A\right] = \frac{F \cdot \cancel{A}}{\cancel{A}} = \frac{W \cdot \cancel{A}}{\cancel{A}} = \text{h.D.A.}$$

Name ______________________

Science IA Hour ____

Date ______________________

Laboratory Problem

PRESSURE AND TOTAL FORCE

PROBLEM:

Determine the most convenient working equation for determing the pressure and total force exerted by solids and liquids.

PROCEDURE:

Solid objects "A" and "B" are composed of wood and of the same average density, 0.757 g./cm^3. Add exactly 100 cm^3 of water to each of the vessels "A", "B", and "C". Perform the measurements necessary to obtain the data summarized in the table below. All data with reference to liquids should exclude the weight of the containing vessels.

DATA:

	D	h	A (base)	V	F_W
# __					
# __					

	D	h	A (base)	V	F_W
Vessel A	1 g/cm^3			100cm^3	
Vessel B	1 g/cm^3			100cm^3	
Vessel C	1 g/cm^3			100cm^3	

ANALYSIS OF DATA:

	PRESSURE		TOTAL FORCE (TF=P·A)	
	$P = \frac{F_W}{A}$	$P = D \cdot h$	$TF = \frac{F_W}{A} \cdot A$	$TF = D \cdot h \cdot A$
Solid # _____				
Solid # _____				
"A"				
"B"				
"C"				

Questions to Consider in the Analysis of the Data

For Each of the Two Solids:

1. How does the pressure taken as F_w/A compare to the pressure taken as $h \cdot D$?

2. How does the TF taken as $F_w/A \cdot A$ compare to TF taken as $h \cdot D \cdot A$?

For the Liquid in Vessels "A", "B", and "C":

1. How does the pressure taken as F_w/A compare to the pressure taken as $h \cdot D$?

2. How does the TF taken as $F_w/A \cdot A$ compare to TF taken as $h \cdot D \cdot A$?

CONCLUSION:

On the basis of your evaluation of the data, write working equations to represent the pressure and total force exerted by solids and liquids.

For Solids: P = TF =

For Liquids: P = TF =

QUESTIONS:

1. Under what conditions is the TF exerted by a solid the same as its $h \cdot D \cdot A$?

2. Under what conditions is the TF that liquids exert upon the base of their containing vessels the same as the weight of the liquid in the vessel?

3. What are the only factors that effect the pressure exerted by liquids?

4. Under what conditions is the total force that a liquid exerts against the base of its containing vessel greater than the weight of the liquid in the vessel?

Science IA
Problem Assignment

Name________________________
Science IA Hour____________
Date Due____________________

PRESSURE AND TOTAL FORCE

INSTRUCTIONS: Write the equation that applies, substitute numbers and units into the equation, solve for the units answer first and then the numerical answer.

SAMPLE PROBLEM: A vessel containing 8 lbs. of mercury, density 13.6 g/cm^3, has a base area of 20 cm^2. The height of the mercury in the vessel = 24 cm. Calculate the pressure and total force exerted upon the base of the vessel.

Given: $D = 13.6\ g/cm^3$
$h = 24$ cm.
$A = 20\ cm^2$

Find: (a) pressure
(b) total force
(c) TF = , , F_W

For liquids, $p = h^{-} \cdot D$ and $TF = h^{-} \cdot D \cdot A$

$$(a)\quad p = h^{-} \cdot D = \frac{24\ cm \cdot 13.6\ g}{cm^{3}\ 2} = \frac{326.4\ g}{cm^2}$$

$$(b)\quad TF = h^{-} \cdot D \cdot A = \frac{24\ cm \cdot 13.6\ g \cdot 20\ cm^2}{cm^3} = 6{,}528\ g$$

1. The difference in the mercury levels in the arms of an open manometer was 18 cm. Calculate the pressure being measured.

2. On January 23, 1960, American scientists and Navy personnel aboard the Trieste bathyscaphe set a record dive of 35,800 feet in reaching the bottom of the Mariana's Trench in the Pacific Ocean. If the average density of the seawater is 65 lbs per ft^3, calculate the pressure in lbs/in^2 that was exerted upon the hull of the vessel at that depth.

3. How many lbs. of force would be required to push open an escape hatch, having an area of 1 ft^2, while submerged at this depth?

4. The water pressure in a city water main has a pressure of 80 pounds per square inch. Calculate the height to which water may be pushed as a result of this pressure.

5. The heel on a pair of women's high fashion dress shoes has an area of 0.04 square inches. Calculate the pressure in pounds per square inch developed beneath this heel when a woman weighing 120 pounds transfers 90 percent of her weight to the heel of one foot while walking.

6. Calculate the total force exerted against the bottom of a pool by the water it contains. The pool slopes uniformly from 3 feet at the shallow end to a depth of 12 feet at the deep end. The sloping length is 100 feet and the width is 60 feet. How does the total force against the bottom compare to the weight of the water in the pool.

7. Calculate the total force exerted against the verticle wall at the deep end of the pool described above.

8. How high a column of mercury, specific gravity 13.6, would exert the same pressure as a column of alcohol, density of 50 pounds per cubic foot, 40 feet high?

Problem Review

Name ______________________

Science IA Hour ____

Date ______________________

INTERACTION RESULTING IN PHYSICAL CHANGE

1. A certain wire, cross sectional area of 0.04 square centimeters and 2 meters long, was found to have an elastic limit of 4,000 grams.

   a. Calculate the tensile strength of this wire in grams per square cm.

   b. Calculate the elastic modulus for a wire of this material which has a cross sectional area of 0.08 square centimeters.

2. The surfaces of a flat glass plate, 6 centimeters on each side, were coated with oil. The plate was then susupended from the 4 centimeter mark of a meter stick. The meter stick was pivoted at the 90 centimeter mark and a weight hangs suspended from the 98 centimeter mark. 968 grams were required to set the system in equilibrium in air. Calculate the additional weight force that would be required to break the glass plate free from the surface of the water. ST = 0.074 grams per centimeter.

3. The surface of Lake Mead, formed behind Hoover Dam, is 530 feet above the base of the dam. What is the pressure at the base of the dam?

4. What pressure in pounds per square inch is indicated by an open manometer in which the difference in water levels is 25 centimeters?

5. The difference in mercury levels in the arms of an open manometer is 10.0 inches. What is the indicated pressure in pounds per square inch?

6. Atmospheric pressure at standard conditions is equal to the pressure exerted by a column of mercury 76 centimeters high. What is the equivalent of this pressure in:

   a. pounds per square inch -

   b. feet of water -

7. Calculate the pressure in pounds per square inch that would be required to force water out of the ballast tanks of a submarine which is cruising at a depth of 400 feet in sea water. Specific Gravity of sea water is 1.04.

8. A pipe, open at one end and closed at the other, is carried beneath the surface of a lake. The pipe was held in a vertical position with the closed end on top. At what depth will the water level inside the pipe reach the half-way mark?

Resource Material

PHYSICAL CHANGES RESULTING FROM INTERACTIONS

Required Reading: Challenges in Science, 527 Ja, pages 55-58

QUESTIONS FOR CONSIDERATION:

1. What is a physical change?

2. Name 5 of the types of physical changes that there are. Example: change of state.

3. How do you recognize a physical change from any other kind of change.

4. What are the 2 parts of a solution?

5. Indicate the type of physical change taking place.

   Sweetening of tea by adding sugar.
   Mercury rises in the thermometer
   Drying of clothes on a clothesline.
   Melting butter.
   Tar is squeezed from spaces in roads in summer.
   Air rises above a hot stove.

6. There are four statements listed below. Place the letter of the statement that best explains the happenings of each problem in front of that problem.

   A. The State of matter, whether solid, liquid, or gas depends upon the amount of heat it contains.

   B. When a material dissolves, its molecules are held in spaces between the molecules of the dissolving liquid.

   C. Objects expand when heated and contract when cooled.

   D. The sun provides the energy which produces physical change in matte

PROBLEMS:

1. Cold air tends to take up less space and to become denser than warm air.
2. Sugar disappears when placed in water.
3. Every solution reaches a point where it will not take in any more of a given chemical.
4. When steam condenses in a radiator it warms the room.
5. Heating the metal lid on a fruit jar may loosen it.
6. Electricity made from water power depends on rainfall.
7. Mercury rises in a thermometer as temperature increases.
8. When water dries from the skin it cools the skin.
9. Ocean water contains at least a little of almost every known mineral.
10. Spaces between railroad rails become smaller on hot days.
11. Ice contains less heat than ice water at the same temperature.
12. Houses make popping noises in very cold weather.
13. Iron may be melted and molded into objects by heating and cooling.
14. Clothing generally dries faster on hot days than on cold days.
15. Water from rivers was safe for early travelers to drink, while it is unsafe today.

PHYSICAL CHANGES RESULTING FROM INTERACTIONS

I. Kinds of Physical Changes

II. Characteristics of Physical Change

III. Criteria for Recognizing Physical Change

A.

B.

C.

LABORATORY PROBLEMS FOR INDIVIDUAL INVESTIGATION

1. elastic modulus

2. coefficients of linear expansion

3. coefficients of volume expansion

4. heats of fusion

5. heats of vaporization

6. heats of sublimation

7. heats of crystallization

8. periodic motion resulting from gravitational attraction

9. the nature of magnetic fields resulting from electron flow

10. coefficients of reflection as a function of texture

11. coefficients of reflection as a function of color

Review Outline

INTERACTION RESULTING IN PHYSICAL CHANGE

I. Physical Quantities Related to the Interaction of Forces.

length
force
time
volume
velocity
specific gravity
weight density
weight force
electric charge
pole strength
*magnetic field strength
*tensile strength
*elastic modulus
*force constant
*surface tension
*total force
*pressure
work
area
temperature

*indicates physical quantities for which working definitions will probably be required on the hour test

II. Words Used to Describe Basic Ideas (Concepts) Associated with Physical Change.

1. Physical Change -

2. Interactions -

3. Cohesion -

4. Adhesion -

5. Elastic Limit -

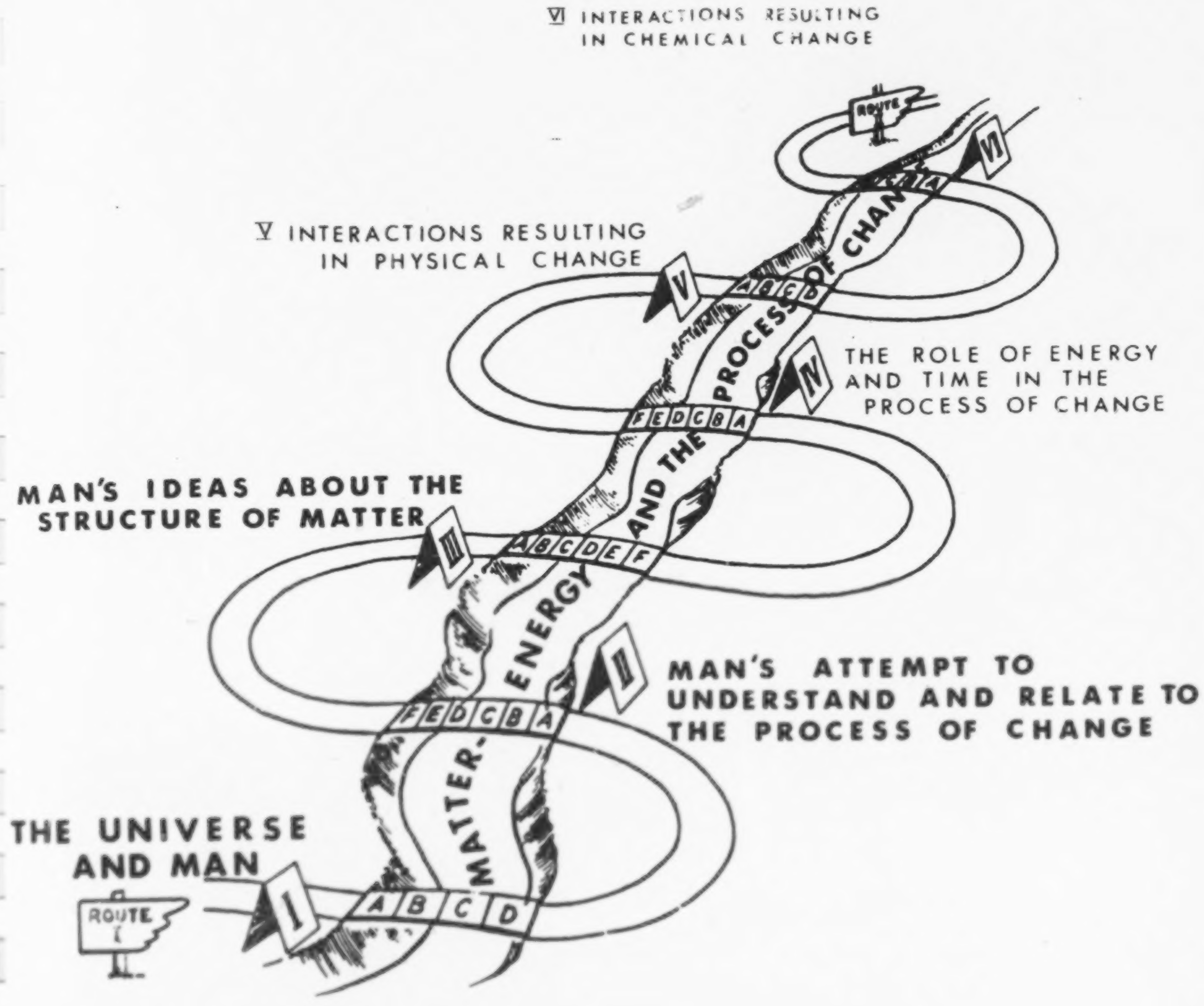
6. Equilibrium -

III. Classification of Forces

1. Nuclear

2. Electromagnetic

3. Gravitational


VI INTERACTIONS RESULTING IN CHEMICAL CHANGE
V INTERACTIONS RESULTING IN PHYSICAL CHANGE
THE ROLE OF ENERGY AND TIME IN THE PROCESS OF CHANGE
MAN'S IDEAS ABOUT THE STRUCTURE OF MATTER
MAN'S ATTEMPT TO UNDERSTAND AND RELATE TO THE PROCESS OF CHANGE
THE UNIVERSE AND MAN
MATTER-ENERGY AND THE PROCESS OF CHANGE
ROUTE I
ROUTE
I
II
III
IV
V
VI
A B C D
F E D C B A
A B C D E F
F E D C B A
A B C D
A

VI. INTERACTIONS RESULTING IN CHEMICAL CHANGE.

A. The Historical Development of Chemical Change.

B. The Nature of Chemical Change..

C. The Chemical Equation, an Expression of Chemical Change.

D. Oxidation, A Fundamental Chemical Process.

THE HISTORICAL DEVELOPMENT OF CHEMICAL CHANGE

The evolution of the concept of chemical change took place over many centuries. Early ideas of this important concept, though inaccurate, were not lacking in imagination, but it was only when the structure of the atom was known that the true nature of chemical change could be understood.

Required Reading:	The Story of Atomic Theory and Atomic Energy, 539.7 F29(L), Phlogiston, Its Rise and Fall, pages 100-111
	A Short History of Chemistry, 540 As, Isomers and Radicals, The Theory of Types and Valence, pages 100-111
Recommended Reading:	Crucibles, The Story of Chemistry, 540 Ja, Paracelsus, pages 20-31

QUESTIONS FOR CONSIDERATION:

1. Explain the meaning of this statement, "While phlogiston fluorished, atoms could make no headway."

2. Lavoisier's balance allowed him to kill phlogiston and discover the Law of the Conservation of Matter. Explain.

3. What was the major difficulty of the phlogiston theory? How was this difficulty handled by the supporters of the theory?

4. What is the Latin meaning of the word "valence"? Why did Frankland make an appropriate choice?

THE HISTORICAL DEVELOPMENT OF CHEMICAL CHANGE

I. Man's Early Ideas About Chemical Change

  A. Ancient Man

  B. Greek Theories

    1. Empedocles

    2. Democritus

    3. Aristotle

II. The Alchemists

  A. Interest in Change

  B. Hg-S Theory and the Philosopher's Stone

  C. Paracelsus

    1. Hg-S Salt Theory

    2. Explanation of Burning

III. The Development of Modern Concepts

  A. Van Helmont

B. Boyle

C. Phlogiston vs. Oxygen

1. Becher-Stahl Team

2. Lavoisier

D. Theories of Affinity

E. Frankland - valence - 1852

F. 20th Century Developments

Review Exercise

Name ____________________

Science I Hour _____

Date ____________________

SYMBOLS AND ATOMIC STRUCTURE

1. Review the list of symbols.
2. Define the following:
   a. atomic number
   b. kernel
   c. atomic weight
   d. octet
   e. inert gas
   f. isotopes
3. For each of the three fundamental subatomic particles give the name, charge, location in the atom and mass number.
4. Sketch atoms represented by the following information.
   a. atomic number = 19
   atomic weight = 39 amu
   b. total number of electrons = 12
   number of neutrons = 12
   c. total number of electrons = 3
   atomic weight = 7 amu
   d. number of neutrons = 14
   atomic weight = 28 amu
   e. number of protons = 11
   atomic weight = 23 amu
   f. number of electrons in L orbit = 4
   atomic weight = 12 amu

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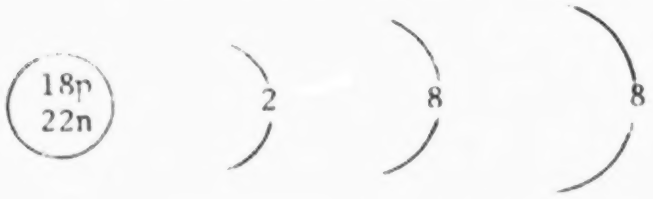
5. An element has 5 electrons in the M orbit and 16 neutrons. Sketch this element.

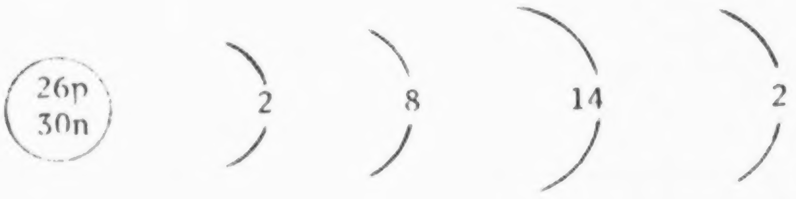
6. Sketch the atom represented by the following isotopic symbol. $^{27}_{13}\mathrm{Al}$

7. The following represents a sketch of the element argon. Write the electron dot symbol for argon.



8. Element X has the following electron dot symbol $\dot{\mathrm{X}}\cdot$
The outer orbit is the N orbit. The atomic weight is 40 amu
Sketch Element X.

9. The following is a sketch of the iron atom. Write the isotopic symbol and electron dot symbol for iron.



10. The common form of sulfur contains 16 protons and weighs 32 amu. Write the isotopic symbol for the isotope of this element which has 17 neutrons.

LABORATORY TECHNIQUES

A. Centrifuging

B. Evaporating a liquid on a glass slide

C. Heating a solid in a test tube

D. Heating a liquid in a test tube

CHEMICAL CHANGES

GENERAL PURPOSE:

To study chemical changes--the agents which cause them, the evidences of chemical change, the energy changes involved in chemical changes, the differences between physical and chemical changes and the final proof of chemical change.

DEFINITIONS:

exothermic - a reaction which continues to release heat after the burner is removed (heat may be needed to start the reaction).

endothermic - a reaction that continually absorbs heat.

catalyst - a substance that changes the speed (slows down or speeds up) of a chemical reaction but takes no part in the reaction itself and remains unchanged.

precipitate - an insoluble solid formed as a result of a chemical reaction (reaction takes place in solutions).

Be careful to follow each procedure exactly and observe accurately. Note especially energy changes and changes in appearance. Record your observations and summarize them in the table at the end of the experiment.

PROCEDURE:

1. Place one spatula of salt (NaCl) in a test tube $\frac{1}{2}$ full of water. Shake to dissolve. Taste the solution. Place one drop of the solution (use dropping pipet) on one end of a glass slide and warm gently high above the flame until the water evaporates. Test the residue on the slide by tasting.

2. Light a wood splint. Record changes which you observe.

3. Fill a dry, small test tube 1/3 full of ammonium dichromate $[(NH_4)_2Cr_2O_7]$. Pour the chemical on an asbestos pad forming a cone shaped pile. Touch a lighted match to the top of the pile. Remove the match as soon as the reaction starts and continues on its own.

4. Place a small amount (one spatula) of mercuric oxide (HgO) in a dry, small test tube. Heat strongly holding the bottom of the tube at the tip of the inner blue cone. Hold a glowing splint near the mouth of the tube while heating. Remove from heat and hold glowing splint near mouth of tube while not heating. Heat again and test with glowing splint as before.

5. Place one spatula of manganese dioxide (MnO_2) in a dry, small test tube. Note the volume which it occupies in the tube. Fill a second t tube ½ full of hydrogen peroxide (H_2O_2). This liquid decomposes very slowly at room temperature into the water and oxygen gas. Look carefully at the liquid to see if you can detect bubbles of oxygen. Now pour the hydrogen peroxide into the tube containing the MnO_2. Note th action and set the tube aside until the action stops. Judge the amou of MnO_2 at the bottom of the tube after the reaction compared with th amount at the start of the experiment.

*EXTRA CREDIT. Design and carry out a procedure which will enable you to compare more precisely the amount of MnO_2 in the tube before and after the reaction.

6. Place a small piece of wax on a glass slide and warm gently. Cool.

7. Add a piece of magnesium ribbon to a test tube one third full of dilu hydrochloric acid (HCl).

8. Add one or two drops of water to a small amount of baking powder in a dry test tube.

9. Place a spatula of salt in a test tube and fill ½ full of water. Shake to dissolve. Add 10 drops of silver nitrate solution ($AgNO_3$). Make your observations and save the resulting mixture for Procedure 10. To keep light from affecting the mixture while standing, wrap paper around the tube and set in a dark place.

10. Centrifuge the mixture from Procedure 9. Pour off the liquid. Remov the solid with the spatula, spread on a piece of paper and expose to a bright light for a few minutes.

11. Observe the demonstration on the electrolysis of water.

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Use the chart to summarize your observations with reference to the preceding investigations. Place a (✓) for those that are true.

PROCEDURE	1	2	3	4	5	6	7	8	9	10	11
heat required to start rection or keep it going											
light energy caused reaction											
electrical energy caused reaction											
the addition of water caused the reaction											
substance present which speeded action but itself remained unchanged											
reaction was exothermic											
reaction was endothermic											
light was given off											
visible bubbles											
a precipitate was formed											
end products chemically different from reacting substances											
original substance could be easily regained											
the change was chemical											
the change was physical											

THE NATURE OF CHEMICAL CHANGE

I. Characteristics of a Chemical Change

   A. Definition of a chemical change - a change in which new substances with new properties are formed.

      1. Secondary properties

      2. Difference between physical and chemical change

   B. Energy changes in chemical change

      1. exothermic

      2. endothermic

      3. activation energy

   C. Agents used to bring about chemical changes

      1. heat

      2. light

      3. electricity

      4. water

      5. catalyst

   D. Evidences of chemical change

      1. Energy released or absorbed

         a. Heat

         b. Light

         c. Electricity

         d. Mechanical

      2. Evolution of a gas

      3. Formation of a precipitate

   E. Final proof of chemical change

      1. Analysis of products

      2. Reversibility of change

Exercise

VALENCE

Symbol	Atomic Number	Atomic Weight	Sketch	Electron Dot Symbol	Valence	Metal or Non-Metal
Na	11	23 amu				
Cl	17	35 amu				
Mg	12	24 amu				
O	8	16 amu				
B	5	11 amu				
He	2	4 amu				
K	19	39 amu				
Al	13	27 amu				
P	15	31 amu				
F	9	19 amu				
H	1	1 amu				
Ca	20	40 amu				
N	7	14 amu				
Si	14	28 amu				
Ne	10	20 amu				
S	16	32 amu				
C	6	12 amu				
Li	3	7 amu				
Be	4	9 amu				
Ar	18	40 amu				

The Nature of Chemical Change (continued)

II. Chemical bonding - compound formation

   A. Valence

      1. Definition - the combining capacity of elements

      2. Kernel and valence electrons

   B. Ionic bonding (electrovalence)

      1. Formation of NaCl

      2. Definition of an ion - an atom or group of atoms (radical) which carries an electric charge

      3. Electron dot and ionic formula for NaCl

      4. Chemical definition of a metal and non-metal

      5. Energy relationships in ionic bonding

         a. Ionization energy - the energy required to remove an electron from an atom

         b. Electron affinity - the energy released when an electron is added to a neutral atom

      6. Formation of $MgCl_2$

   C. Covalent bonding

      1. Normal

         a. Formation of HCl

         b. Electron pair

2. Coordinate

3. Energy relationships in covalent bonding

4. Bonding in the diatomic gases and methane

5. Notation for covalent bonding

6. Double and triple bonds

D. Chemical definition of valence

1. Complete definition - the number of electrons which an atom gains, loses, or shares in bonding with one or more atoms.

2. Valence of free elements

3. Valence - a property only in compounds

4. Neutrality of the molecule

E. Variable valence

1. Cause

2. Nomenclature

   a. Old system

   b. New system

TABLE OF COMMON VALENCES

+1		+2		+3	
sodium	Na^{+1}	magnesium	Mg^{+2}	aluminum	Al^{+3}
potassium	K^{+1}	calcium	Ca^{+2}	ferric	Fe^{+3}
hydrogen	H^{+1}	zinc	Zn^{+2}	chromic	Cr^{+3}
cuprous	Cu^{+1}	ferrous	Fe^{+2}		
lithium	Li^{+1}	cupric	Cu^{+2}		
silver	Ag^{+1}	mercuric	Hg^{+2}		
ammonium	$\boxed{NH_4^{+1}}$	nickel	Ni^{+2}		
		barium	Ba^{+2}		
		lead	Pb^{+2}		

-1		-2		-3	
fluoride	F^{-1}	sulfide	S^{-2}	nitride	N^{-3}
chloride	Cl^{-1}	oxide	O^{-2}	Phosphate	$\boxed{PO_4^{-3}}$
bromide	Br^{-1}	sulfate	$\boxed{SO_4^{-2}}$		
iodide	I^{-1}	carbonate	$\boxed{CO_3^{-2}}$		
nitrate	$\boxed{NO_3^{-1}}$	sulfite	$\boxed{SO_3^{-2}}$		
chlorate	$\boxed{ClO_3^{-1}}$	peroxide	$\boxed{O_2^{-2}}$		
hydroxide	$\boxed{OH^{-1}}$				
bicarbonate	$\boxed{HCO_3^{-1}}$				
nitrite	$\boxed{NO_2^{-1}}$				
acetate	$\boxed{C_2H_3O_2^{-1}}$				
bisulfate	$\boxed{HSO_4^{-1}}$				

☐ denotes radical

The Nature of Chemical Change

F. Formula writing

1. Procedure

2. Formula Notation

a. Subscript

b. Coefficient

c. Radical subscript notation

G. Significance of a formula

1. Empirical and molecular formulas

2. Limitations of valence scheme

a. Non-existent compounds

b. Formula discrepancies

Exercise

FORMULA WRITING

	BICARBONATE	ACETATE	OXIDE	SULFITE	PHOSPHATE	IODIDE	NITRATE
chromic							
lead							
hydrogen							
mercuric							
silver							
ammonium							
ferric							
barium							
cuprous							
calcium							
zinc							
magnesium							
cupric							
potassium							
nickel							
sodium							
ferrous							
aluminum							
lithium							

METAL	peroxide	bisulfate	chloride	sulfate	hydroxide	nitrite	sulfide	chlorate	bromide	carbonate	nitride
chromic											
lead											
hydrogen											
mercuric											
silver											
ammonium											
ferric											
barium											
cuprous											
calcium											
zinc											
magnesium											
cupric											
potassium											
nickel											
sodium											
ferrous											
aluminum											
lithium											

H. Nomenclature

1. Binary compounds

2. Ternary compounds

I. Radicals

1. Definition - a group of covalently bonded atoms which acts as a simple atom in forming an ion

2. Structure of radicals

   a. Oxidation numbers

   b. electron - dot notation and radical structure

Exercise

Name ____________________
Science IA Hour __________
Date Due ____________________

NOMENCLATURE AND OXIDATION NUMBERS

Name the following compounds:

1. $FeSO_4$ ____________________
2. BaO_2 ____________________
3. SO_3 ____________________
4. CBr_4 ____________________
5. $HgCl_2$ ____________________
6. CO ____________________
7. $CuNO_2$ ____________________
8. Bi_2O_5 ____________________
9. CS_2 ____________________
10. $FePO_4$ ____________________
11. $Al(HCO_3)_3$ ____________________
12. Cu_3N_2 ____________________
13. NH_4I ____________________
14. $Zn(C_2H_3O_2)_2$ ____________________
15. Ag_2O ____________________
16. LiOH ____________________

Calculate the Oxidation Numbers of the Indicated Element In the Following Compounds or Radicals.

1. Cl in $HClO_2$ __________
2. I in $NaIO_3$ __________
3. S in SO_3 __________
4. S in SO_3^{-2} __________
5. N in NH_4^{+1} __________
6. Mn in $KMnO_4$ __________
7. S in the sulfate ion __________
8. C in $Al_2(CO_3)_3$ __________
9. Br in $Ni(BrO)_2$ __________
10. P in $Fe_3(PO_4)_2$ __________
11. S in HSO_4^{-1} __________
12. As in H_3AsO_3 __________
13. Si in K_2SiO_3 __________
14. O in the peroxide ion __________
15. B in $B_4O_7^{-2}$ __________
16. Cr in CrO_4^{-2} __________

Exercise

Name ____________________

Science IA Hour ______

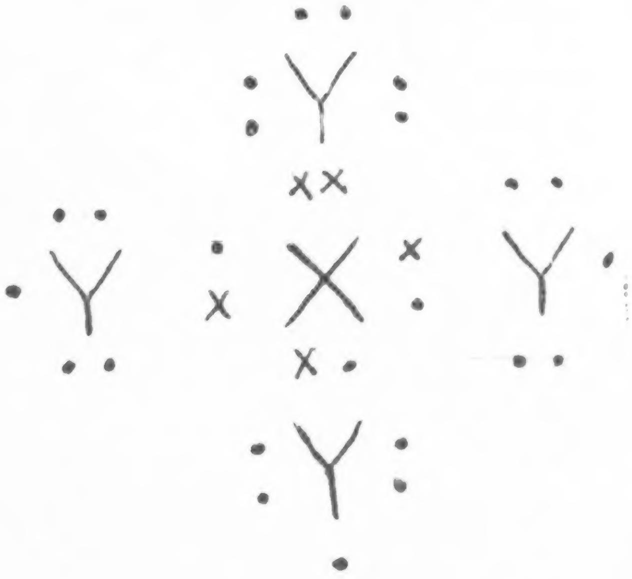
Date Due ________________

STRUCTURE OF RADICALS

Draw the electron dot representations of the following ions or compounds.

1. carbon dioxide
2. the hydroxide radical
3. water
4. the sulfite radical
5. the nitrite radical
6. the bicarbonate radical
7. the ammonia molecule (NH_3)
8. the ammonium ion

Element X combines with Element Y to from a radical whose electron dot representation is given below.



1. What is the oxidation number of Element X? ______
2. What is the valence of the radical XY_4?
3. What types of bonds are present? Indicate their location by labeling on the diagram.

THE CHEMICAL EQUATION AN EXPRESSION OF CHEMICAL CHANGE

I. Word Equations

  A. Qualitative significance

  B. Reactants

  C. Products

II. Formula Equations

  A. Quantitative significance

  B. Procedure in equation writing

    1. representation of facts (written or verbal words)

    2. inclusion of all symbols and formulas

    3. law of conservation of matter

    4. notation

      a. → equality

      b. ↑ gas

      c. ↓ precipitate

      d. Δ

      e. other conditions

  C. Types of equations

    1. combination (binary compounds)

    2. decomposition
      a. heating of metallic oxides
      b. electrolysis of binary compouns

Exercise

Name____________________________
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CHEMICAL EQUATIONS

COMBINATION AND DECOMPOSITION

Write balanced equations for the following chemical reactions:

1. the burning of calcium in oxygen

2. the reaction of nickel with chlorine

3. the heating of gold (III) oxide

4. the burning of hydrogen and oxygen

5. the electrolysis of potassium chloride

6. the reaction of aluminum and sulfur

7. the formation of iron (III) bromide from the elements

8. the heating of silver oxide

9. the electrolysis of chromic fluoride

10. the reaction of barium with nitrogen

11. the reaction of potassium with sulfur

12. the reaction of copper with iodine so that a compound is formed in which copper shows its lowest oxidation state

OXIDATION, A FUNDAMENTAL CHEMICAL PROCESS

The change from a reducing to an oxidizing atmosphere represents an important evolutionary process in the physical universe. In this unit we shall make a detailed study of oxygen, an element which is not only essential to the maintaining of life on earth, but which scientists believe played a vital role in the evolution of life.

Required Reading:	Modern Chemistry, Oxygen, pages 104-118
	Giants of Science, Joseph Priestley and Antonine Lavoisier, pages 113-125
Recommended Reading:	"Ozone - Oxygen's Strange Twin," Science World, May 1, 1963
	Crucibles, the Story of Chemistry, Priestley, pages 32-47, and Lavoisier, pages 62-76

QUESTIONS FOR CONSIDERATION:

1. $Fe + S \rightarrow FeS$ is a well known reaction. Why is this reaction an example of combustion?

2. The electron dot structure for the oxygen molecule is thought to be a deviation from the usual octet. Use sketches to discuss this point. What effect does this structure have on the properties of liquid oxygen?

3. What relationship exists between oxidation in the human body and burning of a fuel? Discuss similarities and differences.

4. Carbon monoxide burns while carbon dioxide does not. Explain.

5. Ozone is an allotropic form caused by a difference in the number of atoms per molecule rather than in the distance between atoms. Explain.

OXIDATION, A FUNDAMENTAL CHEMICAL PROCESS

I. Preparation of oxygen

  A. Laboratory methods

    1. Preparation of oxygen using $KClO_3 + MnO_2$

      a. Decomposition of a chlorate

      b. Use of a catalyst

    2. Preparation of oxygen from HgO

  B. Industrial methods

    1. Electrolysis of water

    2. Liquid air

LABORATORY TECHNIQUES

A. Glass manipulations

  1. Cutting tubing

  2. Fire polishing

  3. Making bends

B. Inserting glass tubing through a rubber stopper

C. Test tube generator

D. Gas collection

  1. Displacement of water

  2. Displacement of air

E. Testing a gas for combustibility

F. Testing a gas for supporting of combustion

OXYGEN

GENERAL PURPOSE:

To prepare oxygen and to study its properties.

PROCEDURE:

1. Place 6 scoops of potassium chlorate and 3 scoops of manganese dioxide (MnO_2) on a piece of paper and mix with the spatula. Set up a test tube generator following the procedure and techniques as demonstrated in class. Be sure to provide for a space above the chemicals and have the tube in a slightly inclined position. At this point have your teacher check your setup before proceeding. Remember to displace the air in the generator before collecting oxygen. Heating should be done by holding the burner in the hand and moving the flame to different positions. Heat gently. If the heating is stopped the delivery tube must be pulled from the trough first. Bottles of oxygen are to be set mouth up. Collect four bottles of oxygen and allow the generator to cool.

2. Hold a bottle of oxygen in a horizontal position and insert a spatula of charcoal which has been heated red hot. Replace the glass plate to trap the product of the reaction. Limewater turns cloudy in the presence of carbon dioxide. Place a few drops of limewater in the bottle and shake.

3. Place a small amount of powdered sulfur on a spatula and light in a burner. Insert in a bottle of oxygen held in a horizontal position. Smell the gaseous product in the bottle.

4. Hold a glowing splint near the mouth of a bottle of oxygen. Observe whether the gas itself seems to explode and burn, or whether it merely makes other things burn.

5. Place a small amount of red phosphorus on a spatula and light in a burner. Insert in a bottle of oxygen.

6. Add a small amount of water to the generator. Crush some of the solid with the stirring rod and mix it with the water. Allow the remaining solid to settle. Using the dropping pipet, place one or two drops of the clear liquid on a glass slide. Holding the slide in your hand evaporate the water by holding above a flame.

7. Place a very small amount of mercuric oxide in a dry, small test tube. Heat. Hold a glowing splint near the mouth of the tube while heating.

QUESTIONS:

1. List five physical properties of oxygen as you observed them or provided for them in this experiment.

2. State whether oxygen supports combustion and whether it burns.

3. Wrtie the formula equation for Procedure 1.

4. Define the term "catalyst".

5. Name the catalyst in this experiment and state whether your observations indicate that it was used up or whether it remains in the generator.

6. Write the formula equation for Procedure 2.

7. Write the word equation for Procedure 3.

8. Write the word equation for Procedure 5.

9. Write the formula equation for Procedure 7.

II. Properties of oxygen

  A. Physical properties

  B. Chemical properties

III. Discovery of oxygen

  A. Priestley

  B. Scheele

IV. Oxidation and combustion

  A. Historical development

    1. The phlogiston theory

    2. Lavoisier's 12-day experiment

  B. Oxygen reactions

153 Summary Sheet

OXYGEN REACTIONS

A. General Rules

1. An element reacting with oxygen forms a binary compound of the element and oxygen is called an oxide.

2. A hydrocarbon burning in air or oxygen produces the common oxide of carbon (CO_2) and the common oxide of hydrogen (H_2O).

B. Special Facts

1. Laboratory preparation of oxygen:

a. $2KClO_3 \xrightarrow[\Delta]{MnO_2} 2KCl + 3O_2\uparrow$

b. $2HgO \xrightarrow{\Delta} 2Hg + O_2\uparrow$

2. Industrial preparation of oxygen (chemical method):

$2H_2O \xrightarrow{e.c.} 2H_2\uparrow + O_2\uparrow$

3. Formulas of the common oxides of some elements

sulfur = SO_2

carbon = CO_2 (CO is formed if carbon is burning in insufficient air)

phosphorus = P_4O_{10}

iron = FeO, formed at 200°C only

= Fe_2O_3, formed at low or room temperature

= Fe_3O_4, formed at high temperature

4. Preparation of ozone

$3O_2 \xrightarrow{e.c.} 2O_3\uparrow$

Exercise

Name ____________________
Science IA Hour ____________
Date Due ____________________

OXYGEN REACTIONS

Write a balanced chemical equation for the following reactions:

1. the burning of carbon in air

2. the burning of methane (CH_4) in air

3. the electrolysis of water

4. the heating of mercuric oxide

5. the oxidation of sulfur

6. the preparation of ozone by passing electricity through air

7. the reaction of iron with oxygen at a high temperature

8. the burning of phosphorus in air

9. heating a mixture of potassium chlorate and manganese dioxide

10. the oxidation of lead

11. the reaction of sodium with oxygen

12. the oxidation of chromium

Oxidation, A Fundamental Chemical Process (continued)

- C. Combustion
    - 1. Kindling temperature
    - 2. Effect of surface area
    - 3. Dust explosions
    - 4. Spontaneous combustion
- D. The true nature of oxidation

V. Ozone

- A. Allotropic form
- B. Occurrence
- C. Preparation
- D. Structure
    - 1. Resonance
    - 2. Hybrid
- E. Properties
    - 1. Physical
    - 2. Chemical
- F. Uses

Exercise - Discussion Questions

Name ______________________
Science IA Hour _____
Date ______________________

OXYGEN

1. Give the formula for elementary oxygen.

2. Write a formula which represents oxygen in the combined state.

3. Give the percent by volume which is dissolved in water and the percent by volume which is normally present in the air. Give the percent by weight of oxygen chemically combined in water. Which of these sources of oxygen is used by animals living in water?

4. Describe the discovery of oxygen. Include the discoverers, dates, chemicals used, source of heat, and the man given credit for naming the gas.

5. Describe briefly the industrial methods for preparing oxygen. Include the chemical equation (if any) and the advantages of each method.

6. Oxygen freezes to a solid at $-218.4^{\circ}C$. Convert this temperature to $^{\circ}F$.

7. List three physical properties of liquid oxygen.

8. Give five uses for oxygen.

9. Make a comparison of the oxyhydrogen and oxyacetylene torches.

10. What was the phlogiston theory?

11. What was Lavoisier trying to prove in his 12 day experiment? How did he proceed to do this?

12. Liquid oxygen or fuming nitric acid are frequently mentioned in the news from Cape Kennedy. For what purposes are these substances used which makes them so important in the activities at this location?

13. What was the principal contribution of Lavoisier to the study of chemistry?

14. Oxidation was originally defined as that process by which oxygen unites with some other substance. Give a broader and more general definition of oxidation.

15. Which has the higher kindling temperature, iron powder or an iron file?

16. Why does increasing surface area increase the rate of combustion?

17. What causes dust explosions?

18. Describe two methods by which water puts out fires.

19. What is the cause of spontaneous combustion?

20. The word "inflammable" was formerly used to mean a substance that would burn. Why was this a poor choice?

21. Ozone is triatomic. Explain.

22. How may ozone be prepared in the laboratory? How is ozone prepared in nature?

23. Draw the electron dot formula for the resonating structures of ozone.

24. Give the physical properties of ozone.

25. What is the outstanding property of ozone?

26. What uses for ozone depend on this outstanding property?

27. What property of ozone limits its use?

28. What the the difference between isotopes and allotropes?

DEFINE THE FOLLOWING TERMS:

1. Oxide
2. Oxidation
3. Combustion
4. Kindling temperature
5. Electrolysis
6. Flame
7. Volatile
8. Allotrope
9. Resonance
10. Hybrid

Review Questions

Name ____________________
Science IA Hour ______
Date Due ______________

INTERACTIONS RESULTING IN CHEMICAL CHANGE

1. Discuss briefly the chemical change theories of Empedocles, Democritus, and Paracelsus.

2. What is the difference between a physical and chemical change?

3. List five agents used to bring about chemical change and three evidences that a chemical change is taking place.

4. A compound has the molecular formula C_2H_4. What is the empirical formula?

5. List two ways that oxygen can be prepared in the laboratory and two ways it can be prepared industrially. Give one advantage of each industrial method.

6. What contribution did Lavoisier make with regard to the element oxygen?

7. What is the cause of spontaneous combustion?

8. Define the following terms:
   a. endothermic
   b. catalyst
   c. exothermic
   d. activation energy
   e. precipitate
   f. valence
   g. radical

h. kernel

i. ionic bond

j. covalent bond

k. kindling temperature

l. subscript

m. coefficient

9. Write the formula for the following compounds:

a. ammonium chloride ____________ d. zinc nitrate ____________

b. cuprous nitride ____________ e. mercuric carbonate ____________

c. calcium sulfide ____________ f. aluminum bromide ____________

10. Name the following compounds:

a. $Cu(OH)_2$ ____________ d. $MgSO_4$ ____________

b. $Fe(NO_2)_3$ ____________ e. Ag_3PO_4 ____________

c. NaF ____________ f. FeO_2 ____________

11. Calculate the oxidation number of the indicated element in the following:

a. F in $NaFO_4$ ____________ c. N in NO^{-1} ____________

b. P in $FePO_4$ ____________ d. As in AsO_4^{-3} ____________

12. Draw the electron dot representation for the following:

a. sulfur dioxide b. the sulfate ion

13. Write balanced equations for the following reactions.

a. the reaction of zinc with iodine -

b. the electrolysis of aluminum chloride -

c. the burning of ethane (C_2H_6) in air -

d. the oxidation of lithium -

e. the burning of carbon in air -

14. List five physical properties of oxygen.

15. What are the main chemical properties of oxygen?

PERIODIC CHART

SHELLS

s — d

LIGHT METALS — TRANSITION

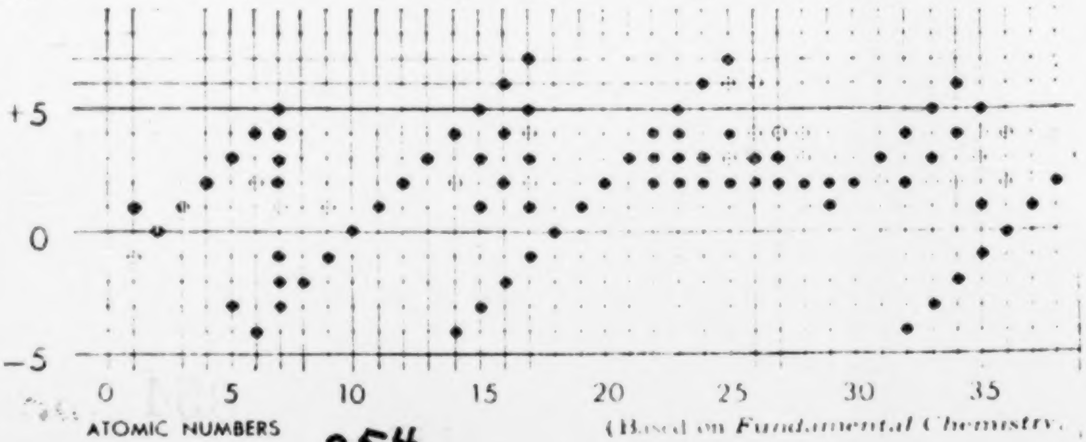
PRINCIPAL QUANTUM No. *n*	X-RAY NOTATION	I A	II A	III B	IV B	V B	VI B	VII B
1	K	1 1 H 1.00797						
2	L	2 1 3 Li 6.939	2 2 4 Be 9.0122					
3	M	2 8 1 11 Na 22.9898	2 8 2 12 Mg 24.312					
4	N	2 8 8 1 19 K 39.102	2 8 8 2 20 Ca 40.08	2 8 9 2 21 Sc 44.956	2 8 10 2 22 Ti 47.90	2 8 11 2 23 V 50.942	2 8 13 1 24 Cr 51.996	2 8 13 2 25 Mn 54.9380
5	O	2 8 18 8 1 37 Rb 85.47	2 8 18 8 2 38 Sr 87.62	2 8 18 9 2 39 Y 88.905	2 8 18 10 2 40 Zr 91.22	2 8 18 12 1 41 Nb 92.906	2 8 18 13 1 42 Mo 95.94	2 8 18 13 2 43 Tc (99)
6	P	2 8 18 18 8 1 55 Cs 132.905	2 8 18 18 8 2 56 Ba 137.34	57-71 See Lanthanide Series	2 8 18 32 10 2 72 Hf 178.49	2 8 18 32 11 2 73 Ta 180.948	2 8 18 32 12 2 74 W 183.85	2 8 18 32 13 2 75 Re 186.2
7	Q	2 8 18 32 18 8 1 87 Fr (223)	2 8 18 32 18 8 2 88 Ra 226	89-100 See Actinide Series				

6 P	LANTHANIDE SERIES (Rare Earth Elements)
7 Q	ACTINIDE SERIES

NOTE: A value given in parentheses denotes the mass number of the isotope of the longest known half-life, or of the best known one.

*The brackets are meant to indicate only the general order of subshell filling. The filling of subshells is not completely regular, as is emphasized by the use of red ink to denote shells which have electron populations different from the preceding element. In the case of He, subshell population is not by itself indicative of chemical behavior, and that element is therefore included in the *inert gas* group, even though helium possesses no p-electrons.

Open circles represent valence states of minor importance, or those



(Based on *Fundamental Chemistry*,

OF THE ELEMENTS

REVISED, 1964

p

HEAVY METALS

NON METALS

INERT GASES

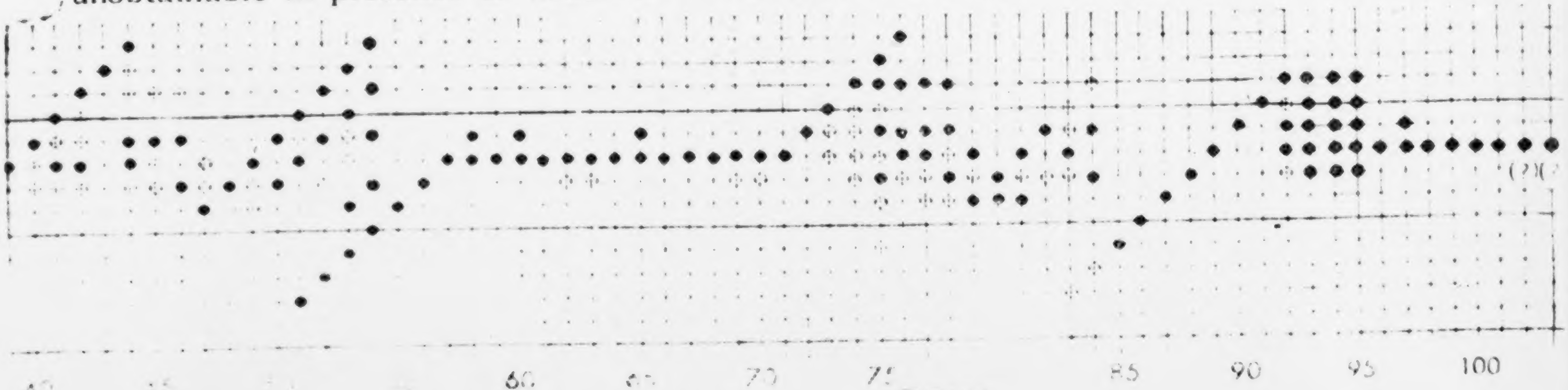
VIII			I B	II B	III A	IV A	V A	VI A	VII A	
										2 He 4.0026 2
					5 B 10.811 2 3	6 C 12.01115 2 4	7 N 14.0067 2 5	8 O 15.9994 2 6	9 F 18.9984 2 7	10 Ne 20.183 2 8
					13 Al 26.9815 2 8 3	14 Si 28.086 2 8 4	15 P 30.9738 2 8 5	16 S 32.064 2 8 6	17 Cl 35.453 2 8 7	18 Ar 39.948 2 8 8
26 Fe 55.847 2 8 14 2	27 Co 58.9332 2 8 15 2	28 Ni 58.71 2 8 16 2	29 Cu 63.54 2 8 18 1	30 Zn 65.37 2 8 18 2	31 Ga 69.72 2 8 18 3	32 Ge 72.59 2 8 18 4	33 As 74.9216 2 8 18 5	34 Se 78.96 2 8 18 6	35 Br 79.909 2 8 18 7	36 Kr 83.80 2 8 18 8
44 Ru 101.07 2 8 18 15 1	45 Rh 102.905 2 8 18 16 1	46 Pd 106.4 2 8 18 18	47 Ag 107.870 2 8 18 18 1	48 Cd 112.40 2 8 18 18 2	49 In 114.82 2 8 18 18 3	50 Sn 118.69 2 8 18 18 4	51 Sb 121.75 2 8 18 18 5	52 Te 127.60 2 8 18 18 6	53 I 126.9044 2 8 18 18 7	54 Xe 131.30 2 8 18 18 8
76 Os 190.2 2 8 18 32 14 2	77 Ir 192.2 2 8 18 32 15 2	78 Pt 195.09 2 8 18 32 17 1	79 Au 196.967 2 8 18 32 18 1	80 Hg 200.59 2 8 18 32 18 2	81 Tl 204.37 2 8 18 32 18 3	82 Pb 207.19 2 8 18 32 18 4	83 Bi 208.980 2 8 18 32 18 5	84 Po (210) 2 8 18 32 18 6	85 At (210) 2 8 18 32 18 7	86 Rn (222) 2 8 18 32 18 8

d

f

57 La 138.91 2 8 18 18 9 2	58 Ce 140.12 [illegible]	59 Pr 140.907 [illegible]	60 Nd 144.24 2 8 18 22 8 2	61 Pm (147) 2 8 18 23 8 2	62 Sm 150.35 2 8 18 24 8 2	63 Eu 151.96 2 8 18 25 8 2	64 Gd 157.25 2 8 18 25 9 2	65 Tb 158.924 2 8 18 26 9 2	66 Dy 162.50 2 8 18 28 8 2	67 Ho 164.930 2 8 18 29 8 2	68 Er 167.26 [illegible]	69 Tm 168.934 [illegible]	70 Yb 173.04 [illegible]	71 Lu 174.97 [illegible]
89 Ac (227) [illegible]	90 Th 232.038 [illegible]	91 Pa (231) 2 8 18 32 [illegible] 9 2	92 U 238.03 2 8 18 32 21 9 2	93 Np (237) 2 8 18 32 22 9 2	94 Pu (244) 2 8 18 32 23 9 2	95 Am (243) 2 8 18 32 24 9 2	96 Cm (247) 2 8 18 32 25 9 2	97 Bk (247) 2 8 18 32 26 9 2	98 Cf (251) 2 8 18 32 27 9 2	99 Es (254) 2 8 18 32 28 9 2	100 Fm (253) 2 8 18 32 29 9 2	101 Md (256) 2 8 18 32 30 9 2	102 No (254)	103 Lw (257)

unobtainable in presence of water. For transuranian elements, all valences reported are listed.



[illegible] G. Deming [illegible] by John Wiley & Sons, Inc.